THE AQUATIC PLANT COMMUNITY OF WOLF LAKE, ADAMS COUNTY 2005-2010

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EXECUTIVE SUMMARY

A study of the aquatic macrophytes (plants) in Wolf Lake was conducted during July 2005 by Water Resources staff of the West Central Region - Department of Natural Resources (DNR) and Adams County Land and Water Conservation. An assessment of the aquatic plant community was conducted in 1948 by state fishery staff. Quantitative surveys were conducted in May 2002 and May 2004 by a private consultant to assess Eurasian watermilfoil colonization using different transect placements. However, 2005 was the first quantitative vegetation study of Wolf Lake by the DNR in the summer. This survey was conducted using the transect method.

A follow-up transect survey was conducted by staff of the Adams County Land and Water Conservation Department in the summer of 2010. A second aquatic plant survey, using the Point Intercept method, was also conducted during the summer of 2010 by Adams County Land & Water Conservation staff.

Wolf Lake is located in Adams County in south central Wisconsin and is a 49-acre natural seepage lake located in the Town of Jackson, Adams County, in the Central Sands Area of Wisconsin, with a maximum depth over 50 feet. This lake has no stream inlet or outlet and is fed by precipitation, runoff and groundwater. The Wolf Lake surface watershed drains approximately 150 acres, which is a 3:1 watershed to lake surface ratio. With such a relatively small watershed, it is likely that shoreline properties contribute more nutrient runoff than the watershed itself. Approximately 1/3 of the shore is owned by the Wisconsin Department of Natural Resources. Approximately 87% of Wolf Lake's shore is covered by native vegetation, including herbaceous, wooded and shrub species.

According to Secchi disk readings for water clarity, plus laboratory testing for total phosphorus and chlorophyll-a, Wolf Lake scores as "mesotrophic" in its phosphorus levels and "oligotrophic" in water clarity and chlorophyll a readings. This state would favor moderate plant growth, only occasional, localized algal blooms and very good water clarity.

In the 2010 transect survey, 50 aquatic species were found. Of these, 50 were native species: 22 emergents; 2 floating-leaf rooted plants; 2 free-floating species; 20 were submergents; and 2 were plant-like algae (*Chara* and *Nitella).* In addition, one invasive emergent plant was found in 2010, *Phalaris arundinacea,* and one invasive submergent plant, *Myriophyllum spicatum).*

The 2010 PI survey found 52 aquatic species. Of these, 50 were native: 24 emergent species; 2 free-floating species; 2 floating-leaf rooted plants; 20 submergent species; and 2 macrophytic algae. The two invasives found were Eurasian watermilfoil and Reed canarygrass, both of which had been found previously at Wolf Lake.

The dominant aquatic species in both surveys was the macrophytic algae, *Chara* spp. (Muskgrass).

The 2010 transect Simpson's Diversity Index score for Wolf Lake was .94, suggesting excellent species diversity. The 2010 PI survey scored .93, which is an excellent level of diversity. The Aquatic Macrophyte Community Index (AMCI) for the 2010 transect survey of Wolf Lake was 58, while that for the PI survey was 59. These figures are above the average range for North Central Wisconsin Hardwood Lakes and all Wisconsin lakes.

MANAGEMENT RECOMMENDATIONS

1) Wolf Lake does have a lot of native vegetated shoreline, but some of the buffers need to be wider landward to get maximum benefit to the water quality, especially with the steep slopes around Wolf Lake.

2) The Wolf Lake Association needs to update its aquatic plant management plan. This plan should be incorporated into the overall lake management plan.

3) Wolf Lake currently has an old aquatic plant management plan, but does not have a lake management plan. The Wolf Lake Association has been considering drafting a lake management plan. It is recommended that the Lake Association develop a lake management plan, so that the lake can be managed as a cohesively. The plan, once written, needs to be regularly reviewed and updated.

4) No lawn chemicals should be used on properties around the lake. If they must be used, they should be used no closer than 50 feet to the shore.

5) Since the native weevils that attack Eurasian watermilfoil were found previously in Wolf Lake, consideration should be given to taking steps to increase the population, if possible. This would reduce the amount of chemicals that need to be used to control the current population of EWM.

6) No broad-scale chemical treatments of native aquatic plant growth are recommended due to the undesirable side-effects of such treatments, including increased nutrients from decaying plant material, destruction of fish and

wildlife habitat, and decreased dissolved oxygen and opening up more areas to the invasion of EWM.

7) Fallen trees should be left at the shoreline. They should not be removed unless they block access to the lake. Recently, a large weeping willow tree fell, which would have provided a great deal of habitat, but it was removed. The lake association could pursue the addition of fallen trees as habitat.

8) Wolf Lake residents should continue to be involved in the Wisconsin Self-Help Monitoring Program to permit on-going monitoring of the lake trends for basically no cost. This should include monitoring for known invasives and a possible hybrid milfoil.

9) Wolf Lake residents should identify, cooperate with and participate in watershed programs that will reduce nutrient and sediment inputs.

10) Emergent vegetation and lily pad beds should be protected where it is currently present and re-established where it is not. These not only provide habitat, but also help stabilize the sandy shores and absorb nutrients.

11) Shore areas where there is undisturbed wooded shore should be maintained & left undisturbed.

12) Since critical habitat areas have been determined on Wolf Lake, care should be taken to reduce any disturbance in those areas. Posting a map of these areas by the boat ramp might help lake users to avoid disturbing these areas.

13) The Wolf Lake Association, with the assistance of the Adams County Land & Water Conservation Department, the Adams County Highway Department, the Wisconsin Department of Transportation and the Town of Jackson should develop and implement protective measures to reduce runoff from Fern Lane into Wolf Lake.

14) The boat ramp should be repaired. As it is, it presents a physical hazard and potential liability.

THE AQUATIC PLANT COMMUNITY FOR WOLF LAKE
ADAMS COUNTY 2005-2010

I. INTRODUCTION

A study of the aquatic macrophytes (plants) in Wolf Lake was conducted during July 2005 by Water Resources staff of the West Central Region - Department of Natural Resources (DNR) and Adams County Land and Water Conservation. An assessment of the aquatic plant community was conducted in 1948 by state fishery staff. Brief surveys were conducted in May 2002 and May 2004 by a private consultant to assess Eurasian watermilfoil colonization using different transect placements. However, 2005 was the first quantitative vegetation study of Wolf Lake by the DNR. This survey was conducted using the transect method.

A follow-up transect survey was conducted by staff of the Adams County Land and Water Conservation Department in the summer of 2010. A second aquatic plant survey, using the Point Intercept method, was also conducted during the summer of 2010 by Adams County Land & Water Conservation staff.

Ecological Role: Information about the diversity, density and distribution of aquatic plants is an essential component in understanding the lake ecosystem due to the integral ecological role of aquatic vegetation in the lake and the ability of vegetation to impact water quality (Dennison et al, 1993). Lake plant life is the beginning of the lake's food chain, the foundation for all other lake life. Aquatic plants and algae provide food and oxygen for fish and wildlife, as well as cover and food for the invertebrates that many aquatic organisms depend on. Plants provide habitat and protective cover for aquatic animals. They also improve water quality, protect shorelines and lake bottoms, add to the aesthetic quality of the lake, and impact recreation.

This study will provide further information useful for effective management of Wolf Lake, including fish habitat improvement, protection of sensitive areas, aquatic plant management, and water resource regulation. The PI data will provide baseline data information that can be used for comparison to future information and offer insight into changes in the lake.

Characterization of Water Quality: Aquatic plants can serve as indicators of water quality because of their sensitivity to water quality parameters such as clarity and nutrient levels (Dennison et al, 1993).

Background and History: Wolf Lake is located in Adams County in south central Wisconsin and is a 49-acre natural seepage lake located in the Town of Jackson, Adams County, in the Central Sands Area of Wisconsin, with a maximum depth over 50 feet. This lake has no stream inlet or outlet and is fed by precipitation, runoff and groundwater. The Wolf Lake surface watershed drains approximately 150 acres, which is a 3:1 watershed to lake surface ratio. With such a relatively small watershed, it is likely that shoreline properties contribute more nutrient runoff than the watershed itself. Approximately 1/3 of the shore is owned by the Wisconsin Department of Natural Resources.

Wolf Lake is part of the Neenah Creek Watershed, a large watershed of 182 square miles from which water flows into the Fox River and eventually into Lake Michigan. Wolf Lake has a public boat ramp, but is designated as a no-motor lake for boat traffic. There are four Native American archeological sites located around Wolf Lake that cannot be further disturbed without permission of the federal government and input from the local tribes.

Eurasian watermilfoil was introduced into Wolf Lake before 2000. By 2001, it had colonized large portions of the watershed in areas up to 20 feet deep (Cason and Roost, 2004). Limited herbicide treatments for controlling the Eurasian watermilfoil were conducted starting in 2001. Since lakewide Eurasian watermilfoil treatments were started in 2002, the acreage of treatment has generally declined. This suggests that the treatments as currently conducted are successful, although some spot chemical treatment has continued to be required through 2010. Monitoring the acreage of milfoil colonization should be continued to ensure that the current management continues to be successful.

A survey was conducted in the summer of 2007 to determine the presence of *Euhrychiopsis lecontei*, a native weevil that uses the exotic Eurasian watermilfoil (*Myriophyllum spicatum)* for several purposes and generally reduces the population of Eurasian watermilfoil in a lake if present in sufficient numbers. Weevil presence was found on 6% of the stems. Research is still being done as to what may be an adequate number of weevils to serve as a check for the growth of Eurasian watermilfoil. However, the 2007 survey did verify the presence of the weevil on Wolf Lake and establish that it possess appropriate habitat for the weevil.

Wolf Lake is accessible off of Adams County Highway A. Residential development in both the surface and groundwatersheds is concentrated along the lakeshore. The surface watershed is about ½ agriculture and ½ woodland use. There are both terrestrial and aquatic Natural Heritage Communities directly south of the lake. Waterfowl, especially ducks, use this lake during spring and fall.

Land Use: Both the surface and ground watersheds of Wolf Lake are fairly small. Overall, the two most common current land uses in the Wolf Lake watersheds are woodlands and residences. In the surface watershed, non-irrigated agriculture is substantial. More than 1/3 of Wolf Lake's shore has wetlands at or near the shore that serve as filters and traps that help keep the lake as clean as it is. Wetlands also play several important roles in maintaining water quality, in the aquatic food chain and in wildlife nesting. It is essential to preserve these wetlands for the health of Wolf Lake.

Soils: Except for some pockets of muck and silt loam, the soils in the surface and ground watersheds for Wolf Lake are loamy sand and sand, with slopes from very flat up to 25%. Sandy soils occupy 15.4% of the ground watershed and 35.3% of the surface watershed. 32.83% of the ground watershed is covered with loamy sand, which also covers 44.6% of the surface watershed. These sandy soils help infiltration of stormwater, reducing runoff amounts.

Fish and Wildlife: A 1948 fishery inventory of Wolf Lake described it as "a small bass lake, fertile, hard water, moderate plankton, with heavy fishing pressure." Bluegills were the most abundant fish found then. At that time, it was also recommended that trout no longer be stocked in Wolf Lake.

Stocking of fish by the WDNR in Wolf Lake started in 1937 with smallmouth bass, perch and bluegill. Annual stocking of bluegills, crappie, largemouth bass and/or perch continued through 1942. Stocking resumed in 1946 with sunfish and largemouth bass and continued through 1949. A few brown trout were stocked in 1991.

A 1963 fish inventory found both largemouth bass and bluegills abundant, with pumpkinseed also common. Rock bass, black crappie and green sunfish were present, but not in great numbers. Yellow perch were scarce. By 1973, yellow perch, black crappie and green sunfish were found in greater numbers, but pumpkinseed and rock bass had become scarce, as were brown bullheads and northern pike. Largemouth bass and bluegills continued to be found in large numbers. Inventories repeated in 1982 and 1996 noted this trend continued: largemouth bass and bluegill found in great numbers, but bullheads, perch, rockbass and pumpkinseed still scarce. Fish cribs were installed in the lake in 1997 to encourage reproduction.

Muskrat and mink are also known to use this area for cover, reproduction and feeding. Seen during the field survey were various types of waterfowl, songbirds, and turkey. Frogs and salamanders are known to use this area for shelter/cover, nesting and feeding. Turtles and snakes also use this area for cover or shelter in this area, as well as nested and fed in this area. A pair of eagles has nested here for the past several years. Sandhill cranes have also nested on Wolf Lake. Upland wildlife feed and nest here as well.

Critical Habitat Areas: Two areas of Wolf Lake have been designated as Critical Habitat Areas. Wisconsin Rule 107.05(3)(i)(I) defines a "critical habitat areas" as: "areas of aquatic vegetation identified by the department as offering critical or unique fish & wildlife habitat or offering water quality or erosion control benefits to the body of water. Thus, these sites are essential to support the wildlife and fish communities. They also provide mechanisms for protecting water quality within the lake, often containing high-quality plant beds. Finally, sensitive areas often can provide the peace, serenity and beauty that draw many people to lakes in the first place. Critical habitat area designations provide information that can be used in developing a management plan for the lake that protects the lake's ecosystem by identifying areas in need of special protection. These areas usually contain several types of aquatic plants: emergent; floating-leaf; rooted floating-leaf; and submergent

Figure 1: Map of Wolf Lake Critical Habitat Areas

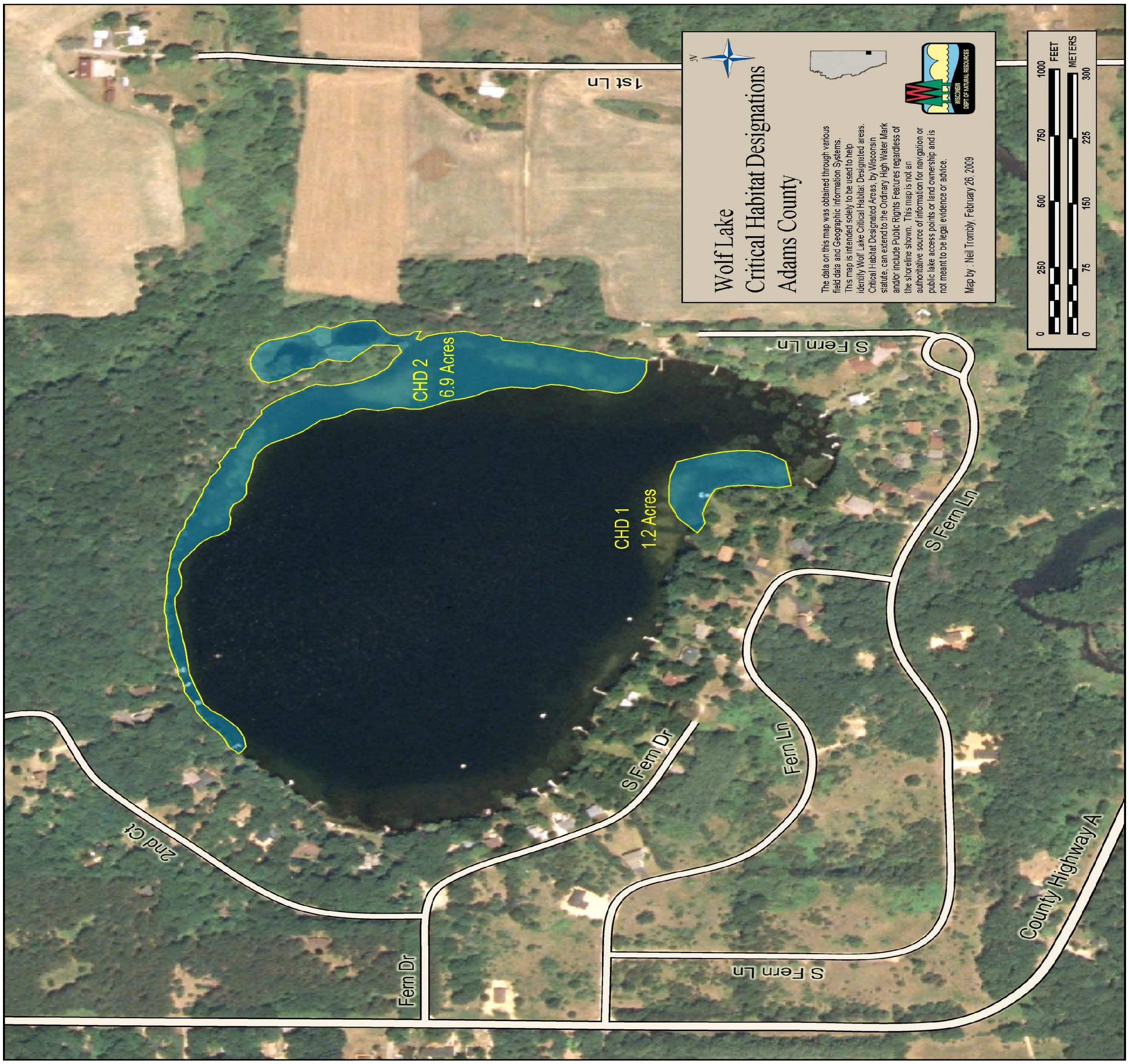


Figure 2. Critical Habitat Designated Areas

Critical Habitat Area WL1

This area extends along approximately 425 feet of the southeastern shoreline of Wolf Lake. 65% of the shore is wooded; 5% is native herbaceous cover; the remaining shore is hard structure and rock riprap. Large woody cover is common for habitat. With little human disturbance along this shoreline, the area has natural scenic beauty.

Figure 2: Photo of Part of WL1

Maximum rooting depth of aquatic vegetation in WL1 was 15 feet. Six types of emergents were found here, as well as two species of rooted floating-leaf plants and eighteen species of submergents. One exotic invasive plant was found in this area: *Potamogeton crispus*

Critical Habitat Area WL2

This area extends along approximately 1900 feet of the northern shoreline. This area extends landward from the shore to cover the deep marsh and wetlands located near the shore. 46.43% of the shore is wooded; 14.28% has shrubs; 20% is native herbaceous cover. The remaining shoreline is rock, cultivated lawn and hard structure. Sedge meadow and deep marsh wetlands are found along this shoreline. Large woody cover is abundant for habitat. With no human disturbance along this shoreline, the area is has natural scenic beauty.

Figure 3: Photo of Part of WL2

Maximum rooting depth in WL2 was 11 feet. No threatened or endangered species were found in this area. Three exotic invasives, *Myriophyllum spicatum* (Eurasian watermilfoil), *Phalaris arundinacea* (Reed Canarygrass) and *Potamogeton crispus* (Curly-Leaf Pondweed), were found in this area. Nine other emergent species were present, as were three species of rooted floating-leaf plants and eight submergent species.

II. <u>METHODS</u>

<u>Field Methods</u>

The 2005 and one 2010 aquatic plant survey study based on the rake-sampling method developed by Jessen and Lound (1962), using stratified random transects. The shoreline was divided into 12 equal sections, with one transect placed randomly within each segment, perpendicular to the shoreline. This method takes samples only in areas of 20 feet in depth or less (littoral zone).

One sampling site was randomly chosen in each depth zone (0-1.5'; 1.5'-5'; 5'-10'; 10'-20') along each transect. Using long-handled, steel thatching rakes, four rake samples were taken at each site. Samples were taken from each quarter around the boat. Aquatic species present on each rake were recorded and given a density rating of 0-5.

A rating of 1 indicates the species was present on 1 rake sample.

A rating of 2 indicates the species was present on 2 rake samples.

A rating of 3 indicates the species was present on 3 rake samples.

A rating of 4 indicates the species was present on 4 rake samples.

A rating of 5 indicates that the species was <u>abundantly</u> present on all rake samples.

A visual inspection and periodic samples were taken between transects to record the presence of any species that didn't occur at the raking sites. Gleason and Cronquist (1991) nomenclature was used in recording plants found.

Shoreline type was also recorded at each transect. Visual inspection was made of 50' to the right and left of the boat along the shoreline, 35' back from the shore (so total view was 100' x 35'). Percent of land use within this rectangle was visually estimated and recorded.

The second method used was the Point Intercept Method. This method involves calculating the surface area of a lake and dividing it (using a formula developed by the WDNR) into a grid of several points, always placed at the same interval from the next one(s). These points are related to a particular latitude and longitude reading. At each geographic point, the depth is noted and one rake is taken, with a score given between 1 and 3 to each species on the rake.

A rating of 1 = a small amount present on the rake;
A rating of 2 = moderate amount present on the rake;
A rating of 3 = large amount present on the rake.

A visual inspection was done between points to record the presence of any species that didn't occur at the raking sites. Gleason and Cronquist (1991) nomenclature was used in recording plants found.

Data Analysis:

The percent frequency (number of sampling sites at which it occurred/total number of sampling sites) of each species was calculated. Relative frequency (number of species occurrences/total all species occurrences) was also determined. The mean density (sum of species' density rating/number of sampling sites) was calculated for each species. Relative density (sum of species' density/total plant density) was also determined. Mean density where present (sum of species' density rating/number of sampling sites at which species occurred) was calculated. Relative frequency and relative density results were summed to obtain a dominance value. Species diversity was measured by Simpson's Diversity Index.

The Average Coefficient of Conservation and Floristic Quality Index were calculated as outlined by Nichols (1998) to measure plant community disturbance. A coefficient of conservation is an assigned value between 0 and 10 that measures the probability that the species will occur in an undisturbed habitat. The Average Coefficient of Conservationism is the mean of the coefficients for the species found in the lake. The coefficient of conservatism is used to calculate the Floristic Quality Index, a measure of a plant community's closeness to an undisturbed condition within its respective eocoregion.

An Aquatic Macrophyte Index was determined using the method developed by Nichols et al (2000). This measurement looks at the following seven parameters and assigns each of them a number on a scale of 1-10: maximum depth of plant growth; percentage of littoral zone vegetated; Simpson's diversity index; relative frequency of submersed species; relative frequency of sensitive species; taxa number; and relative frequency of exotic species. The average total for the North Central Hardwoods lakes and impoundments is between 48 and 57. The maximum score for this scale is 70.

III. RESULTS

Chemical & Physical Data

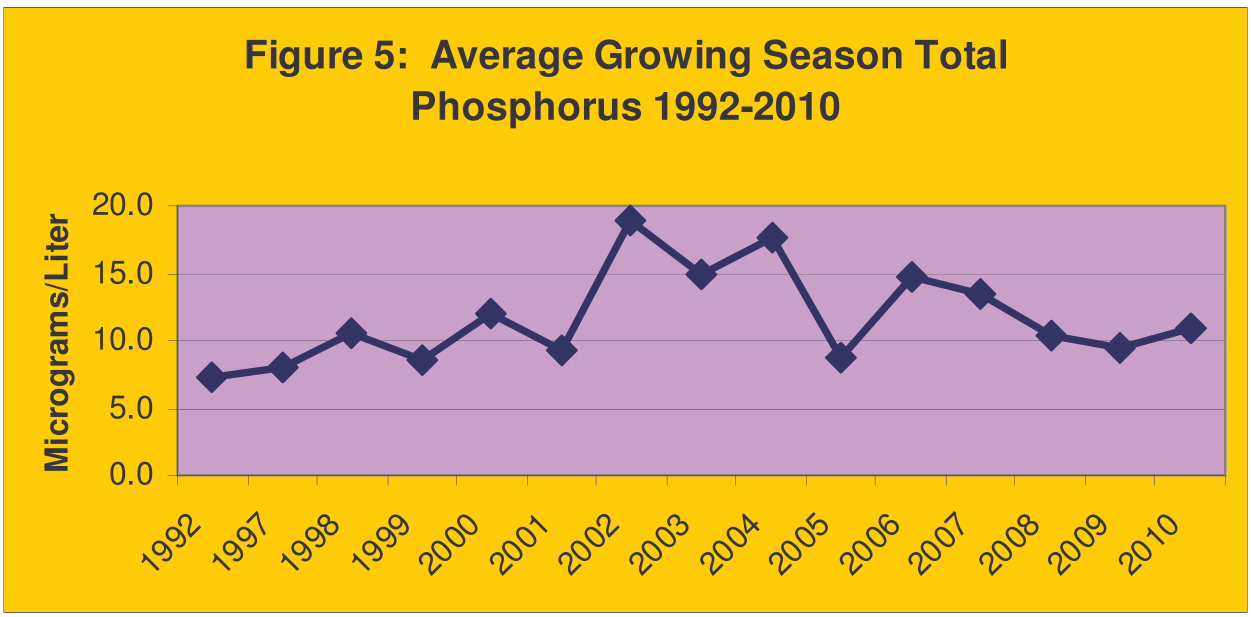
The aquatic plant community can be impacted by several physical parameters. Water quality, including nutrients, algae and clarity, influence the plant community; the plant community in turn can modify these boundaries. Lake morphology, sediment composition and shoreline use also affect the plant community.

The trophic state of a lake is a classification of water quality (see Figure 4). Phosphorus concentration, chlorophyll a concentration and water clarity data are collected and combined to determine a trophic state. Eutrophic lakes are very productive, with high nutrient levels and large biomass presence. Oligotrophic lakes are those low in nutrients with limited plant growth and small fisheries. Mesotrophic lakes are those in between, i.e., those which have increased production over oligotrophic lakes, but less than eutrophic lakes; those with more biomass than oligotrophic lakes, but less than eutrophic lakes; those with a good and more varied fishery than either the eutrophic or oligotrophic lakes.

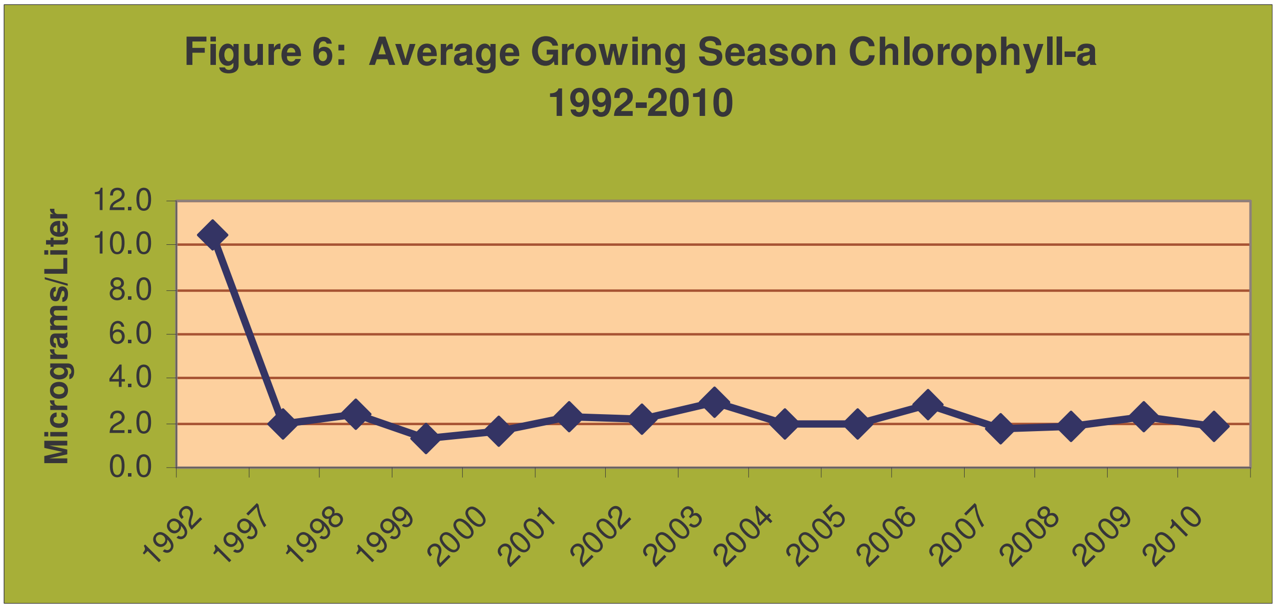
Figure 4: Trophic State Parameters

Trophic State	Quality Index	Phosphorus	Chlorophyll a	Sechhi Disk
		(ug/l)	(ug/l)	(ft)
Oligotrophic	Excellent	<1	<1	>19
	Very Good	1 to 10	**1 to 5**	**8 to 19**
Mesotrophic	Good	**10 to 30**	5 to 10	6 to 8
	Fair	30 to 50	10 to 15	5 to 6
Eutrophic	Poor	50 to 150	15 to 30	3 to 4
Wolf Lake		**11.7**	**2.7**	**16.3**

The limiting factor in most Wisconsin lakes, including Wolf Lake, is phosphorus. Measuring the phosphorus in a lake system thus provides an indication of the nutrient level in a lake. Increased phosphorus in a lake will feed algal blooms and also may cause excess plant growth. The 1992-2010 summer average phosphorus concentration in Wolf Lake was 11.7 micrograms/liter. Wolf Lake's average total phosphorus is below the recommended 20 micrograms/liter to avoid full-lake algal blooms. This places Wolf Lake in the "very good" water quality section for natural lakes and in the mesotrophic level for phosphorus.

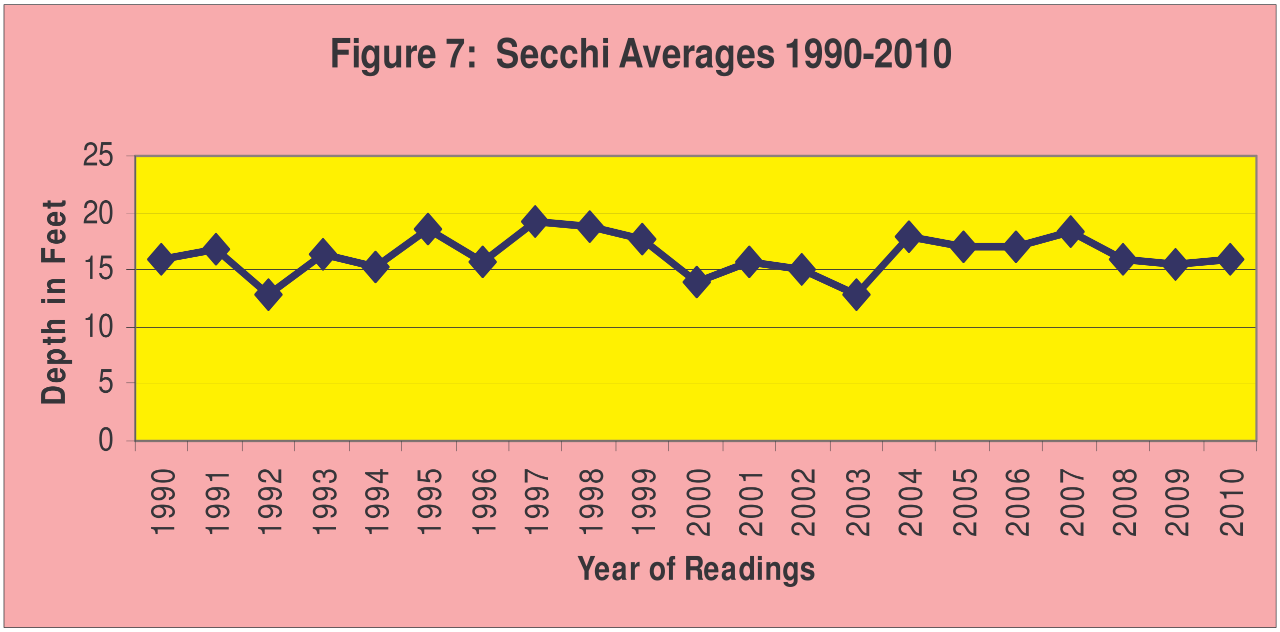


Chlorophyll concentrations provide a measurement of the amount of algae in a lake's water. Algae are natural and essential in lakes, but high algal populations can increase water turbidity and reduce light available for plant growth. The 2004-2010 summer average chlorophyll concentration in Wolf Lake was 2.7 micrograms/liter. This is very low, placing Wolf Lake at the oligotrophic level for chlorophyll a results.



Water clarity is a critical factor for plants. If plants don't get more than 2% of the surface illumination, they won't survive. Water clarity can be reduced by turbidity (suspended materials such as algae and silt) and dissolved organic chemicals that color or cloud the water. Water clarity is measured with a Secchi disk. Secch readings have been kept on Wolf Lake continuously since 1990. Average summer (May-September) Secchi disk clarity in Wolf Lake in 1990-2010 was 16.3 feet. This is good to very good water clarity, putting Wolf Lake into the oligotrophic category for water clarity.

It is normal for all of these values to fluctuate during a growing season. They can be affected by human use of the lake, by summer temperature variations, by algae growth & turbidity, and by rain or wind events. Phosphorus tends to rise in early summer, than decline as late summer and fall progress. Chlorophyll a tends to rise in level as the water warms, then decline as autumn cools the water. Water clarity also tends to decrease as summer progresses, probably due to algae growth, then decline as fall approaches.



According to these results, Wolf Lake scores as "mesotrophic" in its phosphorus levels and "oligotrophic" in water clarity and chlorophyll a readings. This state would favor moderate plant growth, occasional algal blooms and very good water clarity.

Lake Morphology: Lake morphology is an important factor in distribution of lake plants. Duarte & Kalff (1986) determined that the slope of a littoral zone could explain 72% of the observed variability in the growth of submerged plants. Gentle slopes support higher plant growth than steep slopes (Engel 1985).

Wolf Lake is a fairly round basin that gradually slopes into a small deep section just past the center towards the northwest "corner" of the lake. In this area, there are quicker dropoffs in depth than along the south shore. With the high water clarity in the lake, plant growth may be favored in more of Wolf Lake than one might expect since the sun can get to a fair amount of the sediment to stimulate plant growth.

Sediment: Sediment composition can also affect plant growth, especially those rooted. The richness or sterility and texture of the sediment will determine the type and abundance of macrophyte species that can survive in a particular lake. The dominant sediment in Wolf Lake was marl, especially at depths greater than 10 feet. A hard, high-density sediment, sand, was common in the shallow zone; and mixed with silt, it was dominant in the shallow zone. Silt/marl mixtures were common at depths of 1.5-10 feet.

Figure 8: Sediment Composition—Wolf Lake

Sediment Type		0-1.5' Depth	1.5-5' Depth	5-10' Depth	10-20' Depth	Percent of all Sample Sites
Soft Sediments	Marl		21%	33%	83%	33%
	Silt/Marl		36%	50%	17%	25%
	Silt	14%	36%	17%		17%
Mixed Sediments	Sand/Silt	50%	7%			15%
Hard Sediments	Sand	36%				10%

The sediment in Wolf Lake is quite varied. Although sand sediment may limit growth, all sandy sites in Wolf Lake were vegetated. In fact, all sample sites were vegetated in Wolf Lake, no matter what the sediment, so it appears that sandy sediment is not a limiting factor at Wolf Lake.

Shoreland: Shoreline land use often strongly impacts the aquatic plant community and thus the entire aquatic community. Impacts can be caused by increased erosion and sedimentation and higher run-off of nutrients, fertilizers and toxins applied to the land. Such impacts occur in both rural and residential settings.

During the transect surveys in 2005 and 2010, shore cover was estimated visually. Native herbaceous vegetation was the shoreline cover of the highest mean coverage in 2010, while native wooded vegetation was the highest in 2005. One plus is that disturbed sites, such as those with traditional lawn, rock/riprap, hard structures and pavement, were common in 2005, covering a significant portion of the shoreline (35.4% in 2005), but had been substantially reduced in 2010 to only about 12% coverage.

Figure 9: Shoreland Land Use--% Cover—Wolf Lake

Type	2005	2010	Change	% Change
Herbaceous	21.8	38.7	16.9	77.5%
Shrub	10.0	11.2	1.2	12.0%
Wooded	32.1	37.2	5.1	15.9%
Bare Sand	0.7	1.3	0.6	85.7%
Cultivated Lawn	30.4	7.2	-23.2	-76.3%
Hard Structure	3.9	4.1	0.2	5.1%
Rock/Pavement	1.1	0.3	-0.8	-72.7%

Macrophyte Data

SPECIES PRESENT

In the 2005 transect survey, 32 aquatic species were found in Wolf Lake: 30 were native and 2 were exotic imports. In the native plant category, eight were emergent, two were floating-leaf rooted plants, and twentyt-two were submergent. One macrophytic (plant-like) algae, *Chara* spp. (muskgrass) was found at nearly all the sample sites. A second macrophytic algae, *Nitella* spp, was found in two places. No endangered or threatened species were found. Twp exotic invasives, *Myriophyllum spicatum* (Eurasian Water Milfoil) and *Potamogeton crispus* (Curly-Leaf Pondweed), were found.

In the 2010 transect survey, 50 aquatic species were found. Of these, 50 were native species: 22 emergents; 2 floating-leaf rooted plants; 2 free-floating species; 20 were submergents; and 2 were plant-like algae (*Chara* and *Nitella).* In addition, one invasive emergent plant was found in 2010: *Phalaris arundinacea* (which was not found in 2005). One invasive found in 2005 was not found in 2010: *Potamogeton crispus.* However, since it is a plant that dies off by mid-summer, but the 2010 survey wasn't done until August, it may be present in the lake still, as it was found in 2005 when the survey was done earlier in the summer. The invasive Eurasian watermilfoil *(Myriophyllum spicatum)* was found in the 2010 transect survey, as it was in the 2005 survey, at a slightly lower frequency than the 2005 figure. While in 2005, it was found with 26.9% frequency, the frequency of occurrence in 2010 was down to 23.3%.

The 2006 Point Intercept survey was conducted by the WDNR. 24 aquatic species were found. Of these, 21 were native species: 6 emergents; 1 free-floating plant; 1 floating-leaf rooted plant; 9 submergents; and 2 plant-like algae, *Chara* and *Nitella.* Three invasive species were found: Eurasian watermilfoil *(Myriophyllum spicatum)* and Curly-Leaf Pondweed *(Potamogeton crispus)*, both submergents, and the emergent Reed Canarygrass (*Phalaris arundinacea*).

The 2010 PI survey found 52 aquatic species. Of these, 50 were native: 24 emergent species; 2 free-floating species; 2 floating-leaf rooted plants; 20 submergent species;

and 2 macrophytic algae. The two invasives found were Eurasian watermilfoil and Reed canarygrass, both of which had been found previously at Wolf Lake.

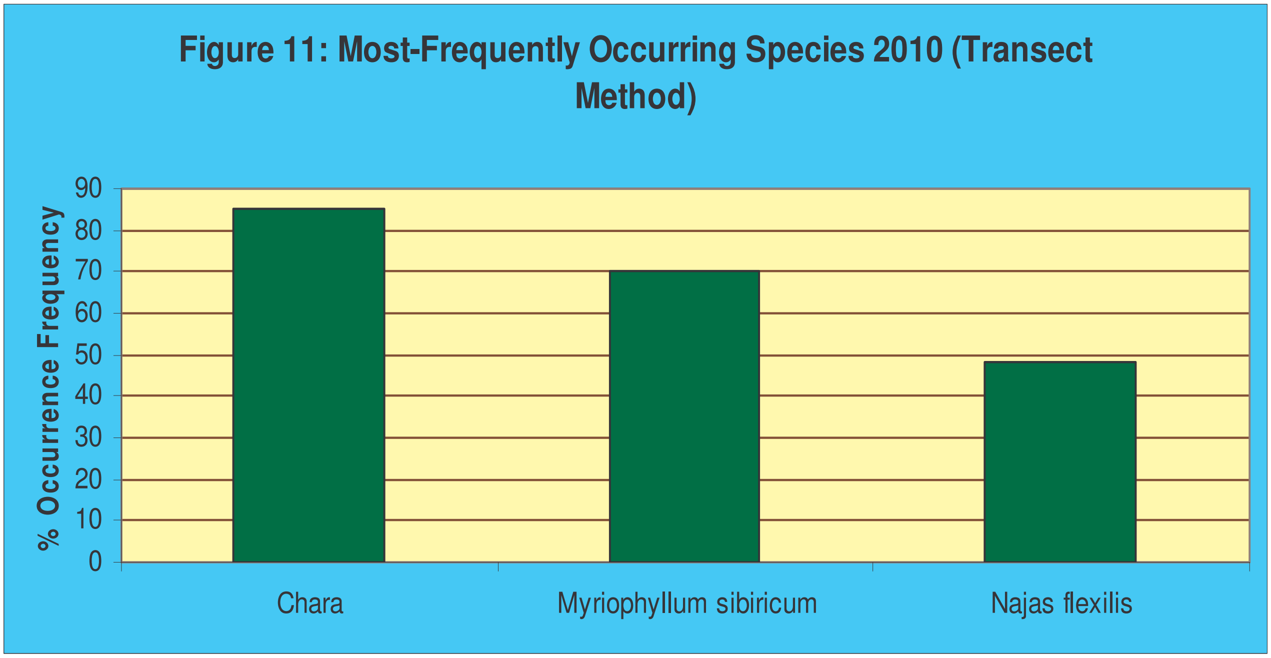
Figure 10—Plant Found in Wolf Lake, 2005-2010

		2005 (t)	2006 (pi)	2010(t)	2010 (pi)
Freshwater sponge			x		
Freshwater green algae					x
SCIENTIFIC NAME	**COMMON NAME**				
Ascelpias incarnata	Swamp Milkweed				x
Aster umbellatus	Hairy Flat-Topped Aster				x
Bidens comosus	Swamp Tickseed			x	x
Bidens frondosus	Common Beggars-Tick			x	
Calamagrostis canadensis	Bluejoint Grass	x			
Carex spp	Sedge	x		x	x
Carex comosa	Bristly Sedge				x
Ceratophyllum demerusum	Coontail	x	x	x	x
Chara spp.	Muskgrass	x	x	x	x
Cicuta bulbifera	Bulb-Bearing Water Hemlock			x	x
Cornus racemosa	Gray Dogwood			x	
Dulchium arundinacea	3-Way Sedge			x	
Eleocharis acicularis	Needle Spikerush	x		x	
Eleocharis palustris	Common Spikerush	x	x	x	x
Elodea canadensis	Common Waterweed	x	x	x	x
Epilobium coloratum	Cinnamon Willow-Herb			x	
Eupatorium perfiolatum	Boneset			x	x
Euthamia graminifolia	Grass-Leaved Goldenrod			x	x
Impatiens capensis	Jewelweed			x	x
Iris versicolor	Blue-Flag Iris		x	x	x
Juncus spp	Rush			x	x
Lemna minor	Lesser Duckweed		x	x	x
Lycopus uniflorus	Northern Bugleweed			x	x
Myriophyllum heterophyllum	Various-Leaf Milfoil			x	x
Myriophyllum sibiricum	Northern Milfoil	x	x	x	x
Myriophyllum spicatum	Eurasian Watermilfoil	x	x	x	x
Najas flexilis	Bushy Pondweed	x	x	x	x
Najas guadalupensis	Southern Naiad	x		x	x
Nitella spp.	Stonewort	x	x		x
Nymphaea odorata	White Water Lily	x	x	x	x
Phalarais arundinacea	Reed Canarygrass		x	x	x
Polygonum amphibium	Water Smartweed	x		x	x
Polygonum lapthifolium	Heart's Ease			x	x
Potamogeton amplifolius	Large-Leaf pondweed	x	x	x	x
Potamogeton crispus	Curly-Leaf Pondweed	x	x		

Potamogeton diversifolius	Water-Thread Pondweed	x			
Potamogeton foliosus	Leafy Pondweed	x		x	x
Potmageton friesii	Fries' Pondweed			x	x
Potamogeton gramineus	Variable-Leaf Pondweed	x	x	x	x
Potamogeton illinoensis	Illinois Pondweed	x	x	x	x
Potamogeton natans	Floating-Leaf Pondweed	x	x	x	x
Potamogeton praelongus	White-Stemmed Pondweed	x	x	x	x
Potamogeton pusillus	Small Pondweed		x		x
Potamogeton richardsonii	Clasping-Leaf Pondweed	x		x	x
Potamogeton robbinsii	Fern Pondweed	x			
Potamogeton zosteriformis	Flat-Stemmed Pondweed	x	x	x	x
Ranunculus longirostris	White Water Crowfoot	x			
Sagittaria latifolia	Common Arrowhead	x	x	x	x
Salix spp	Willow			x	
Schoenoplectus spp	Bulrush		x		
Schoenoplectus pungens	Chairmaker's Rush			x	
Schoenoplectus tabernaemontani	Soft-Stemmed Bulrush	x		x	
Scirpus atrovirens	Black Bulrush				x
Scirpus pendulus	Rufous Bulrush				x
Solanum dulcamara	Bitter Nightshade			x	x
Spirodela polyrhiza	Greater Duckweed			x	
Stuckenia pectinata	Sago Pondweed	x		x	x
Traidenum fraseri	Bog St John's Wort				x
Typha spp	Cattail	x	x	x	x
Utricularia gibba	Creeping Bladderwort			x	
Utricularia minor	Lesser Bladderwort			x	
Utricularia vulgaris	Greater Bladderwort			x	x
Vallisneria americana	Water Celery			x	x
Verbena hastata	Blue Vervain				x
Wolffia columbiana	Common Watermeal				x
Zosterella dubia	Water Stargrass	x		x	x

FREQUENCY OF OCCURRENCE

Chara spp. was the most frequently-occurring aquatic species in Wolf Lake in 2005 and in 2010 in the transect surveys. In 2005, *Elodea canadensis* and *Najas guadelupensis* were also very common. By the 2010 transect survey, *Myriophyllum sibiricum* had moved into second place after *Chara* spp, with *Najas flexilis* as the third most frequently-occurring aquatic species.



In the 2006 PI survey, *Najas flexilis* was the most frequently-occurring aquatic plant on Wolf Lake, with *Elodea canadensis* the second-most frequently-occurring plant. By the 2010 PI survey, *Chara* spp had moved from an occurrence frequency of just under 14% overall to being the most frequently-occurring species, occurring at more than 43%. The next most frequently-occurring species in 2010 were *Myriophyllum sibiricum* and *Ceratophyllum demersum.* In both 2006 and 2010, the emergent species tended to have low frequency of occurrence.

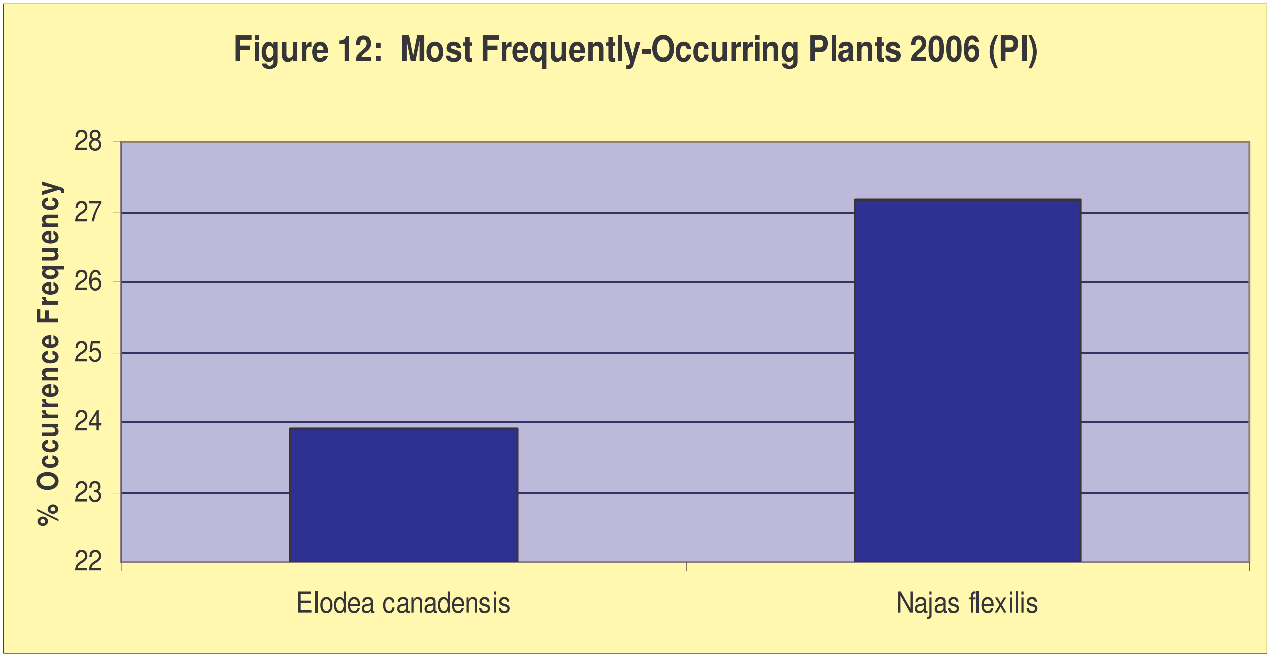


Figure 12: Most Frequently-Occurring Plants 2006 (PI)
% Occurrence Frequency
28
27
26
25
24
23
22
Elodea canadensis
Najas flexilis

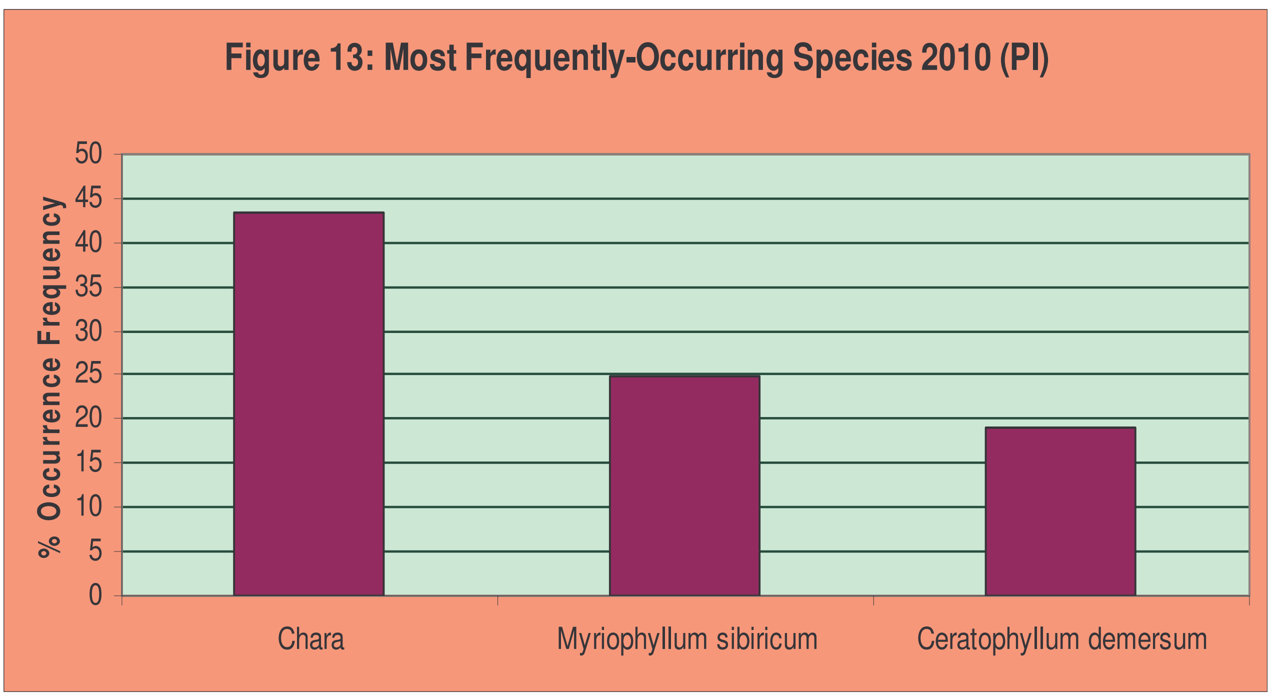


Figure 13: Most Frequently-Occurring Species 2010 (PI)
% Occurrence Frequency
50
45
40
35
30
25
20
15
10
5
0
Chara
Myriophyllum sibiricum
Ceratophyllum demersum

DENSITY OF GROWTH

Chara spp was the species with the highest mean density of growth in Wolf Lake in both the 2005 and 2010 transect surveys. In the 2005 survey, *Najas guadelupensis* and *Elodea canadensis* were close to *Chara* but no other species found in the 2010 transect survey grew at a density close to *Chara* spp.

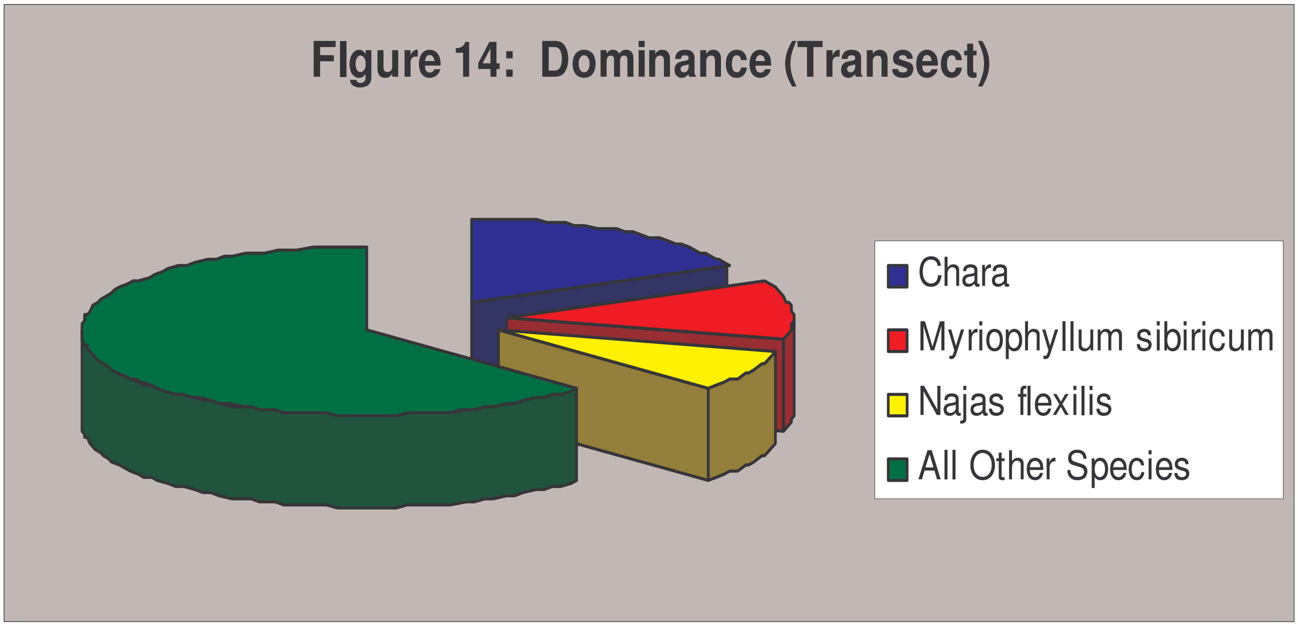
In the 2006 PI survey, *Najas flexilis* had the highest density of growth, followed by *Chara* spp and *Ceratophyllum demersum* considerably behind. The 2010 PI survey showed *Chara* spp as the aquatic species with the highest growth density. No other aquatic species were near it in growth density.

As with frequency of occurrence, emergent plants tended to occur at low growth densities in all four surveys.

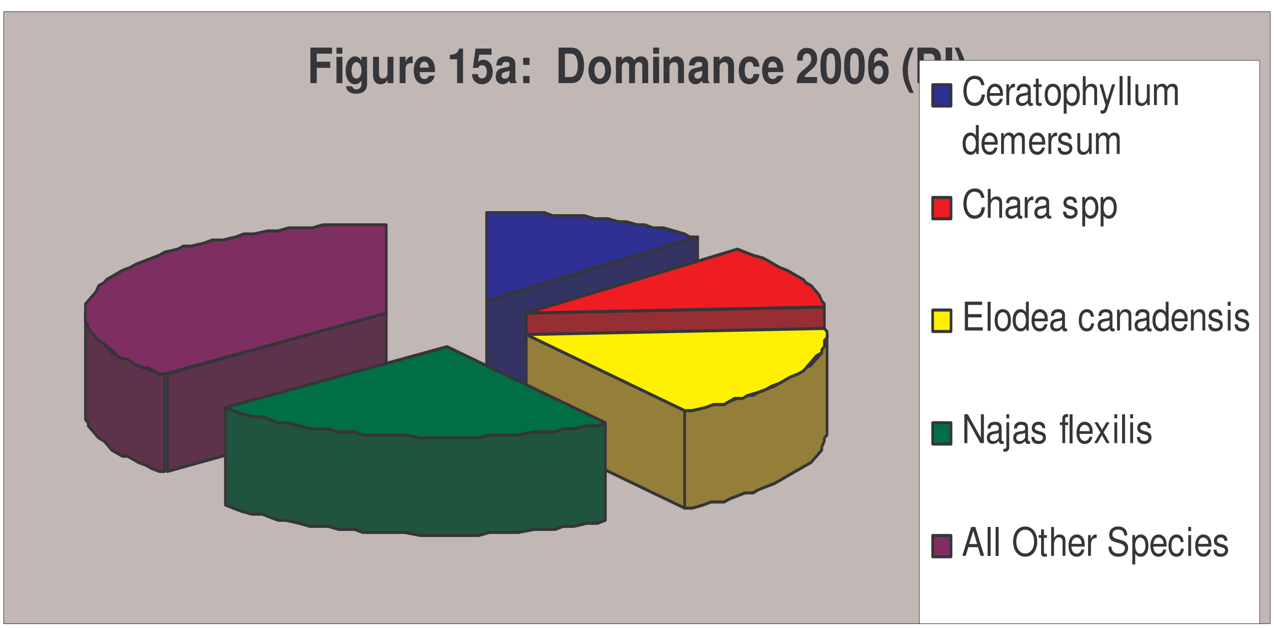
DOMINANCE

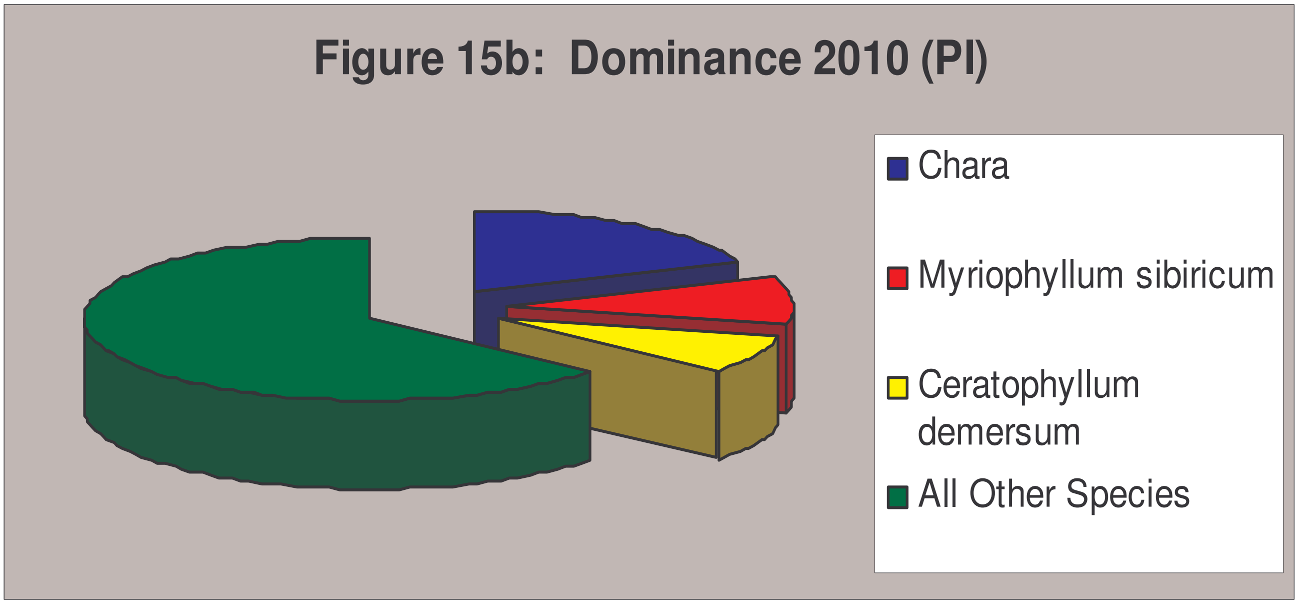
Relative frequency and relative density are combined into a dominance value that demonstrates how dominant a species is within its aquatic plant community. Based on dominance value, *Chara* spp was the dominant aquatic plant species in Wolf Lake Lake in 2005. Sub-dominant were *Elodea canadensis* and *Najas guadelupensis.* These three species together comprised 42% of the lake's aquatic plant community in 2005.

In the 2010 transect survey, *Chara* spp. was again the dominant aquatic species. Subdominant was *Myriophyllum sibricum* and *Najas flexilis.* These three species comprised 32% of the aquatic plant community in the 2010 transect survey.



The two PI surveys also had different species that dominated the aquatic plant community between the 2006 and 2010 surveys. In 2006, the dominant species was *Najas flexilis*, with *Elodea canadensis* sub-dominant. By 2010, the dominant species was *Chara* spp, with no other species close enough to be called sub-dominant.





IV. DISCUSSION

Aquatic plants occurred at 100% of the sample sites in Wolf Lake during the 2010 transect survey to a maximum rooting depth of 18 feet.   The 2005 transect survey also found rooted aquatic plants at all sample sites. Rooted-floating-leaf plants were found in only in the two shallowest zones in both 2005 and 2010.

The 0-1.5 feet depth zone produced the most frequently occurring and densest plant growth. Occurrence frequency and growth density then dropped off as samples sites were at a greater depth, although plants were still found in those depths.   By the 10 to 20 foot depth zone, frequency of occurrence was about one-fourth of what it was in the shallowest zone and growth density was less than one-half of what it was in the shallowest zone.

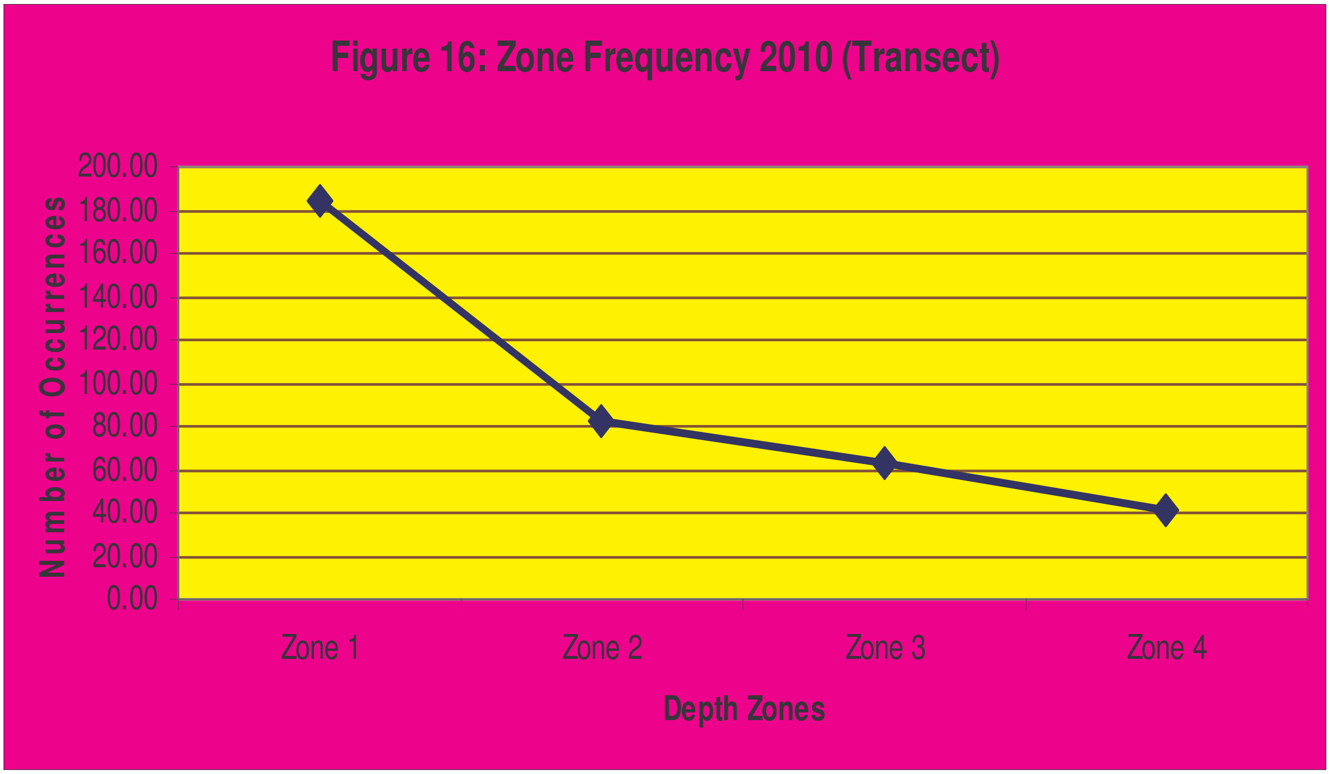


Figure 16: Zone Frequency 2010 (Transect)
Number of Occurrences
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Zone 1
Zone 2
Zone 3
Zone 4
Depth Zones

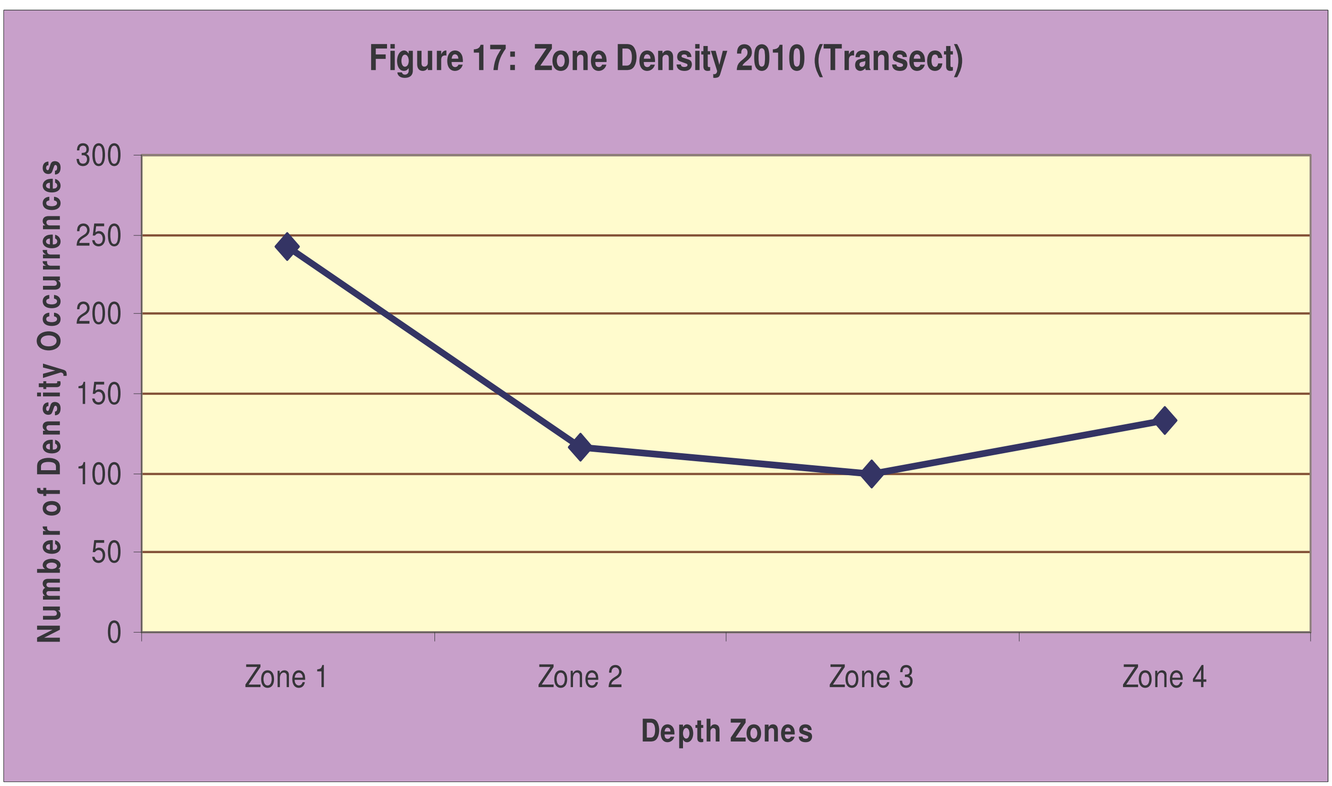
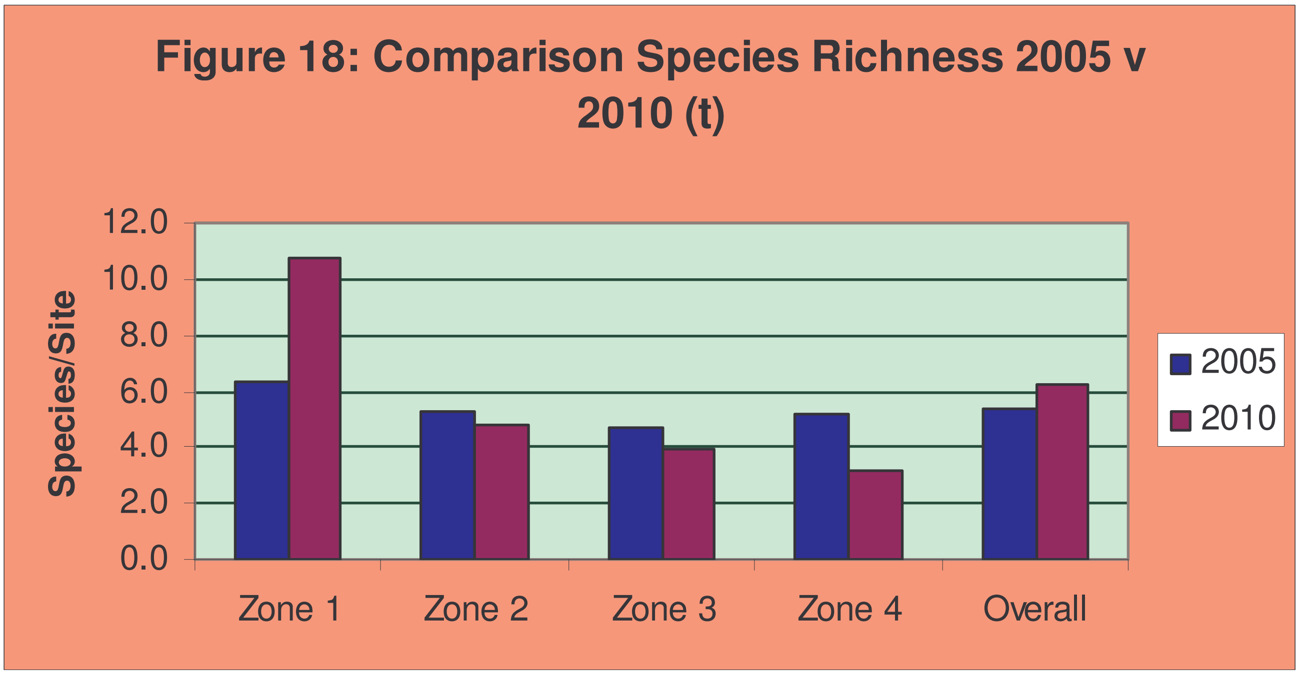


Figure 17: Zone Density 2010 (Transect)
Number of Density Occurrences
300
250
200
150
100
50
0
Zone 1
Zone 2
Zone 3
Zone 4
Depth Zones

Overall species richness (number of species per sample site) for the 2010 transect survey was 6.2 per site. Zone 1 (0-1.5 feet) had a species richness of 10.8. Species richness declined as depth increased: Zone 2 (1.5-5 feet) had a species richness value of 4.8, which declined to 3.9 for Zone 3 (5-10 feet), then down to 3.2 for Zone 4 (10-20 feet).



The following maps outline the approximate areas of the lake where different species types were found during the 2010 transect and point intercept surveys. Considering the number of species found in Wolf Lake in 2010, individual species maps would be confusing, especially since most of the emergent plants were sparse. Further information about specific species is available from the Adams County Land & Water Conservation Department.

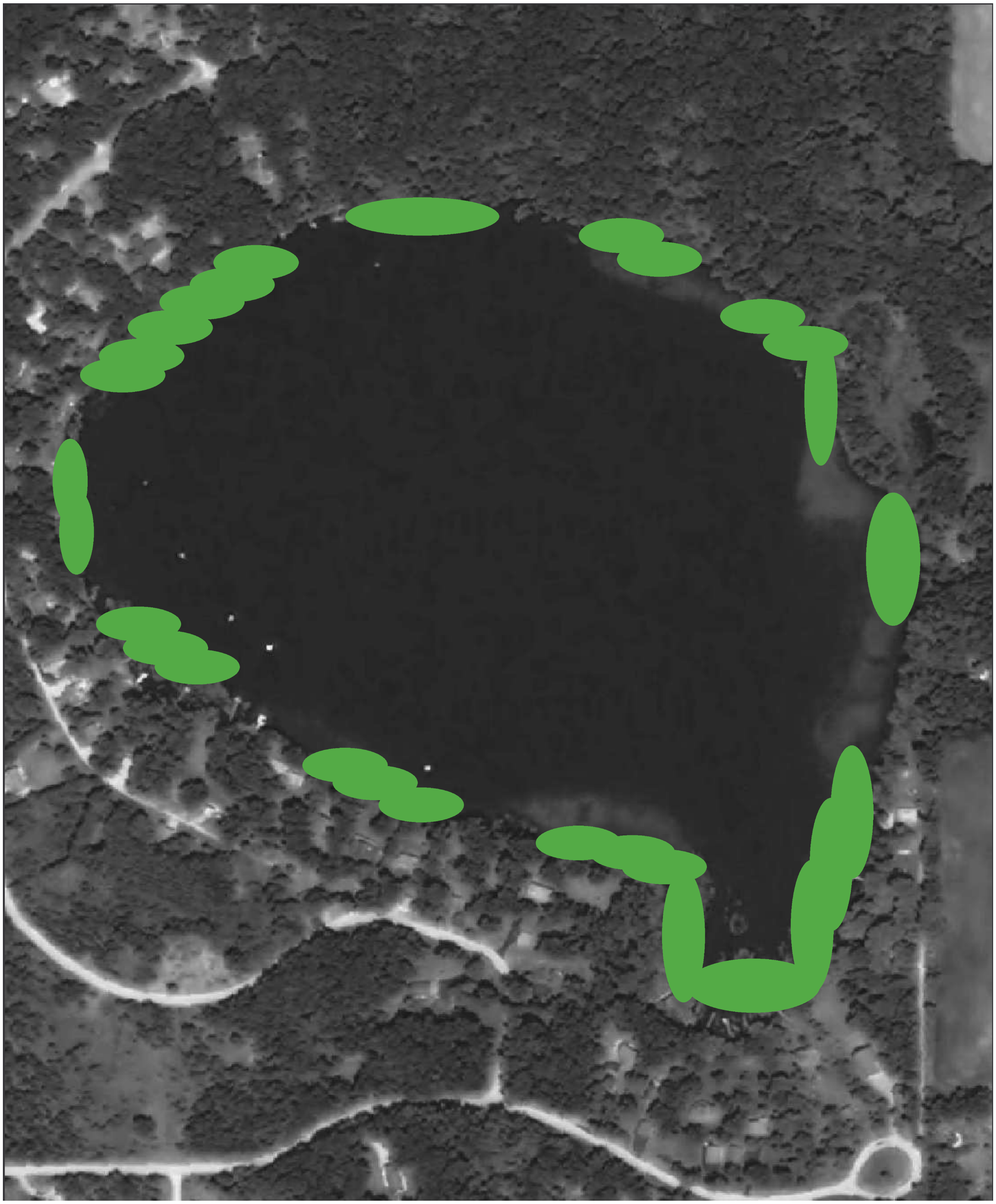


Figure 19: Distribution of Emergent Plants in Wolf Lake 2010 (T) in green

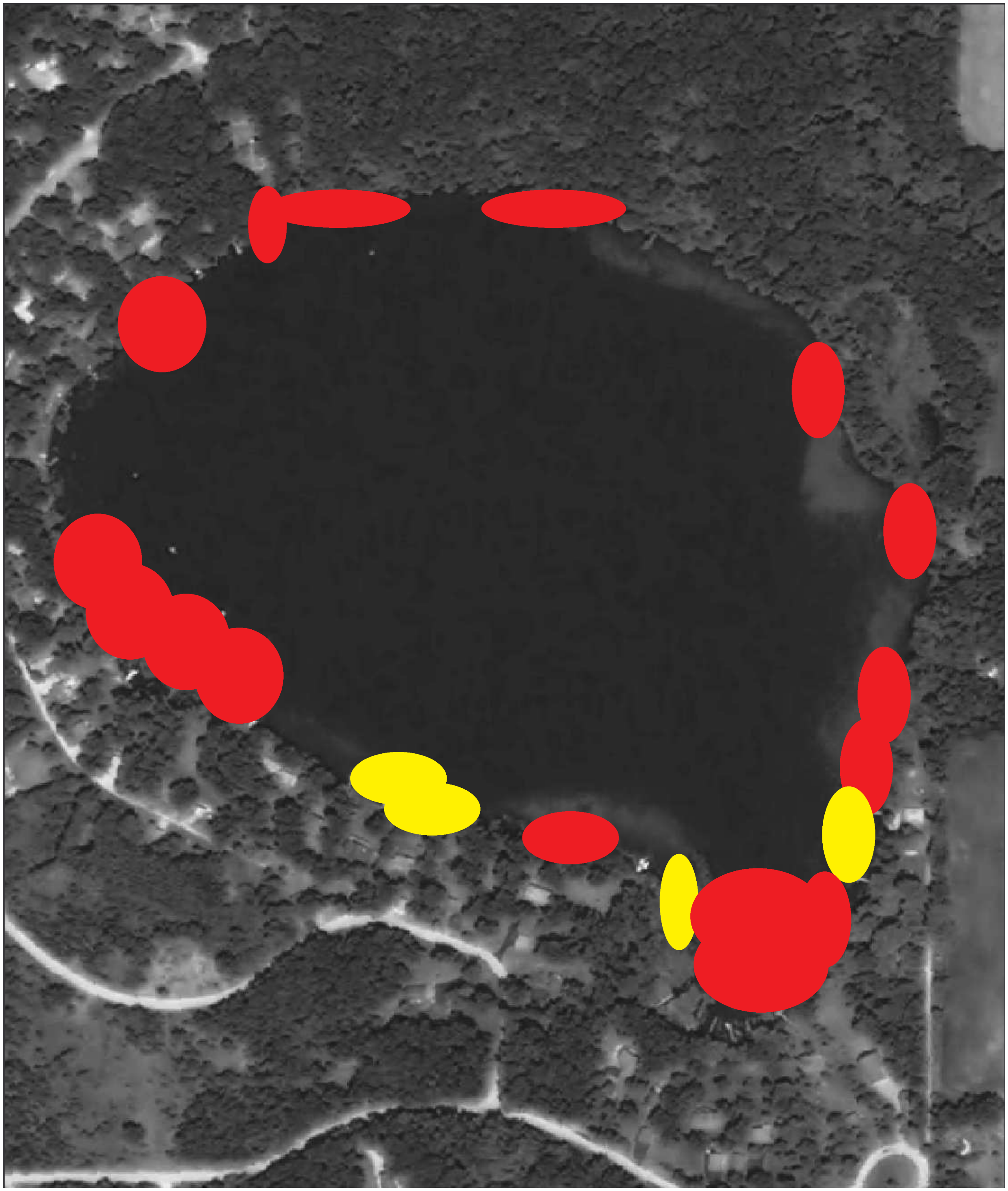
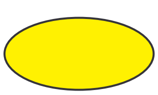
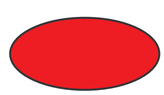


Figure 20: Distribution of Free-Floating & Floating Leaf Rooted Plants (T)



Free-Floating Plants Found



Floating-Leaf Rooted Plants Found

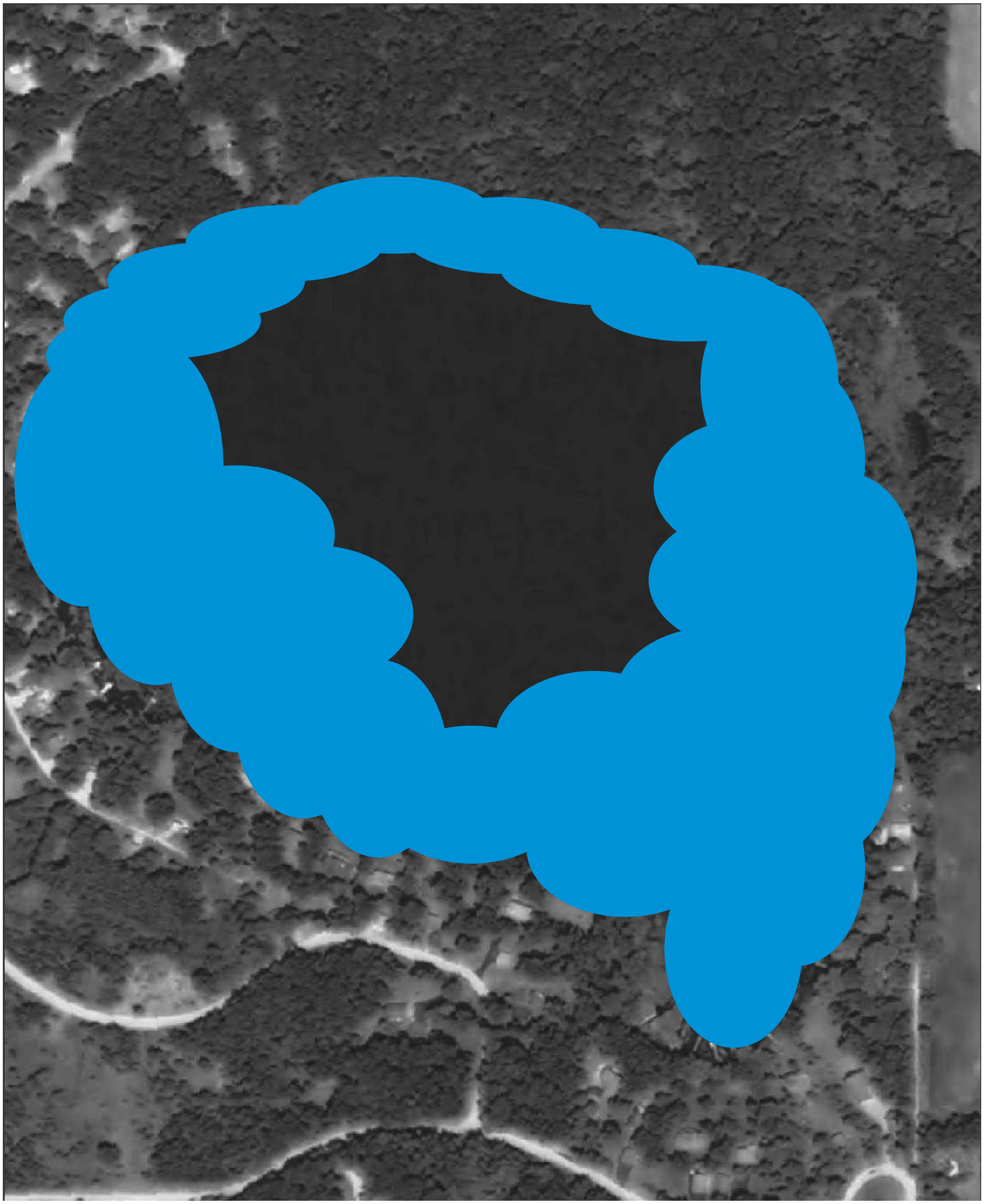


Figure 21: Distribution of Submergent Plants in Wolf Lake 2010 (T) in blue

Only about 76% of the sample sites 25 feet or less in depth in the 2006 PI survey were vegetated. The deepest rooted plant in the 2006 PI survey was found at 22.5 feet. It was *Elodea canadensis* (Common waterweed), a native plant. In the 2010 PI survey, about 78% of the sample sites 25 feet or less in depth were vegetated. The deepest rooted plant in 2010 was found in a depth of 20 feet. It was *Myriophyllum sibiricum* (Northern milfoil), a native plant.

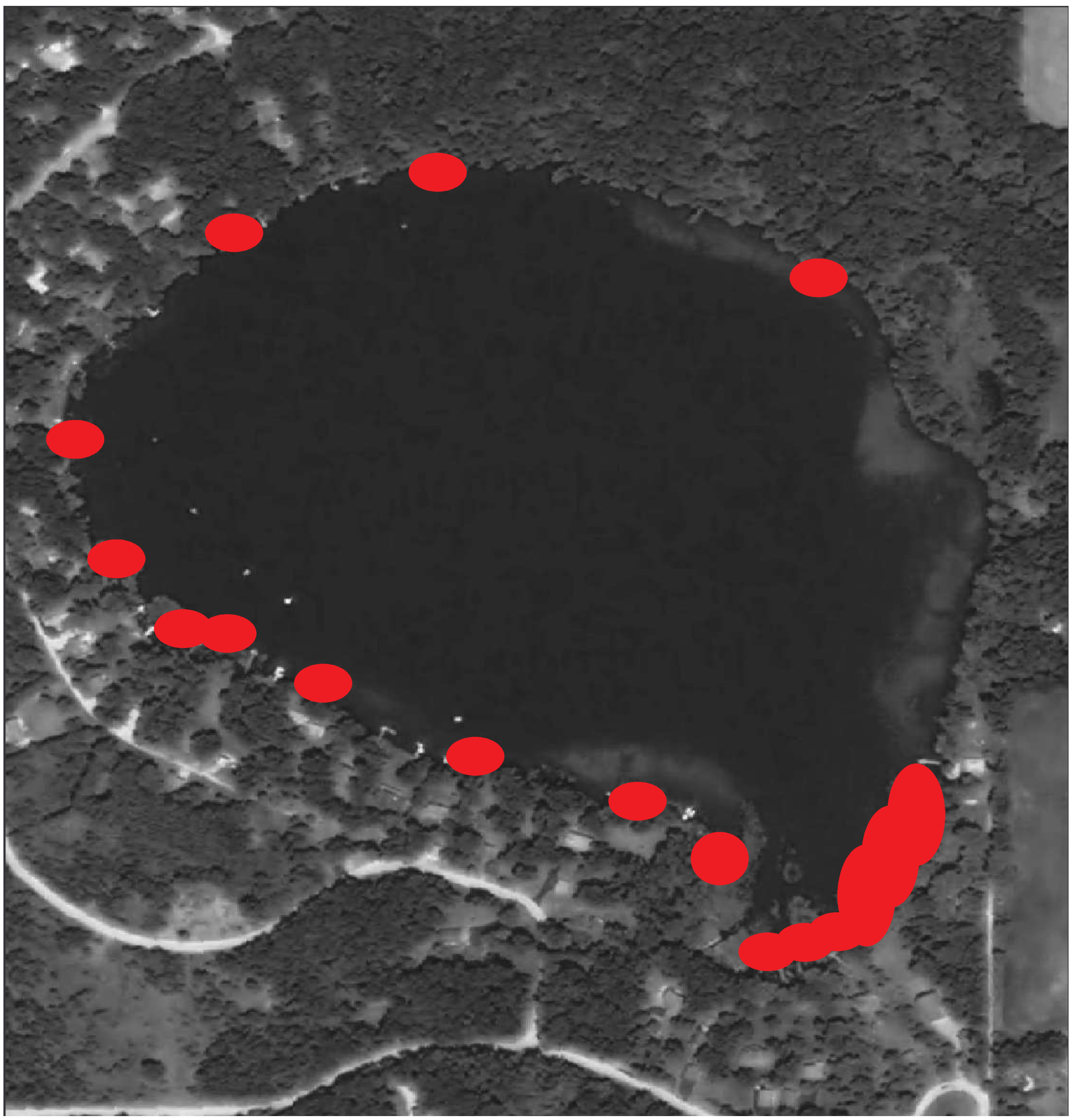


Figure 22: Distribution of Emergent Plants in Wolf Lake 2010 (PI) in red

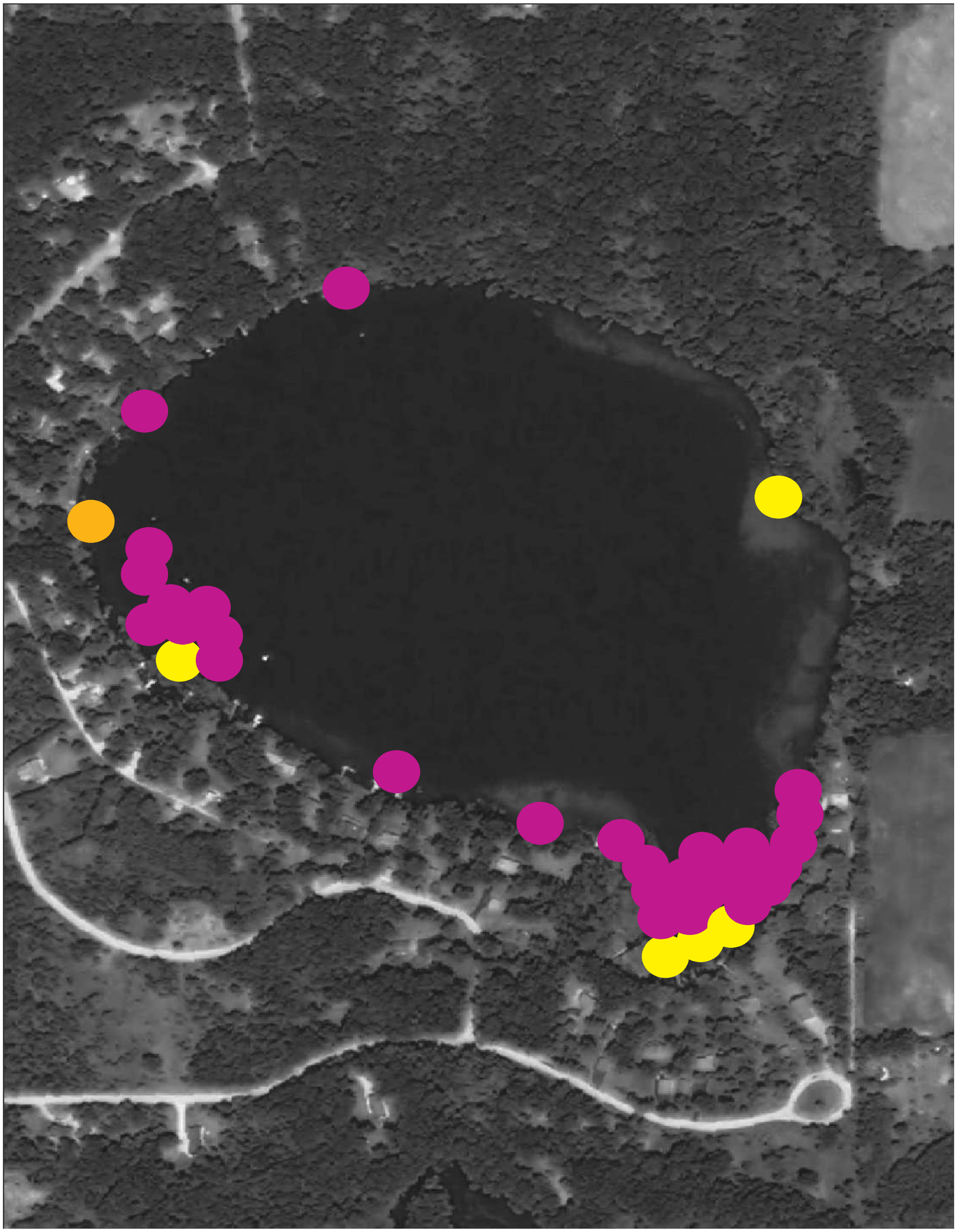


Figure 23: Distribution of Floating-Leaf Rooted Plants and Free-Floating Plants in Wolf Lake 2010 (PI)

Eooted Floating-Leaf Plants Found | **Free-Floating Plants Found** | **Both Types Found**

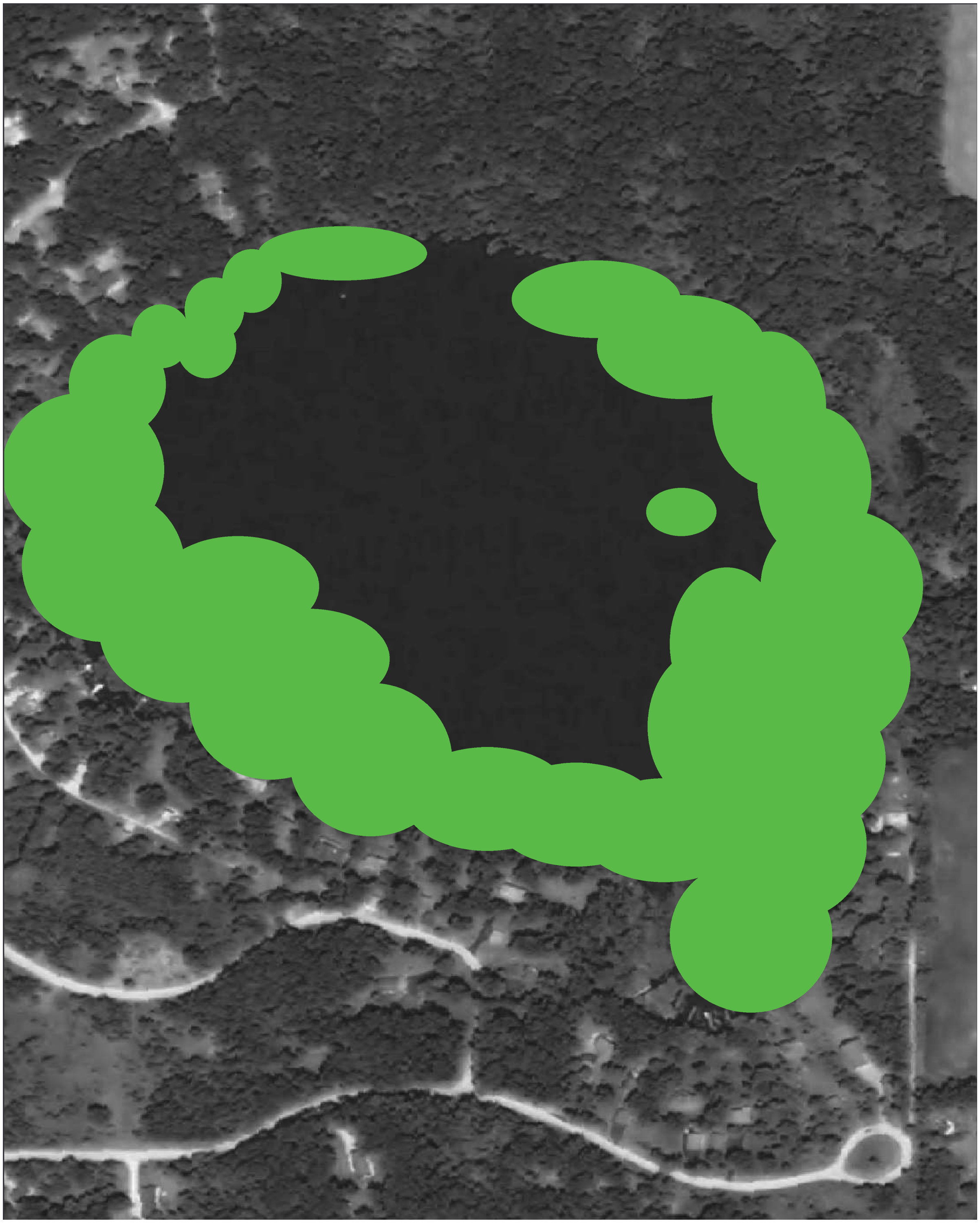


Figure 24: Distribution of Submerged Aquatic Plants in 2010 (PI) in green

Three invasive plants have been found on Wolf Lake since 2000: *Myriophyllum spicatum* (Eurasian watermilfoil); *Phalarais arundinacea* (Reed canarygrass); and *Potamogeton crispus* (Curly-leaf pondweed). The latter two have been found in low occurrence frequency and low growth density, but Eurasian watermilfoil has been on ongoing issue because of its significant presence in the plant community. Its actual presence varies from year-to-year, due to a variety of factors like weather, water temperature, disturbance, etc.

Eurasian watermilfoil occurred at 26.9% of the sample sites in the 2005 transect survey, with 5% overall relative frequency. By the 2006 PI survey, it was down to 3.2% occurrence, with 2% overall relative frequency. In the 2010 transect survey, it occurred at 23.3% of the sample sites, with 4% relative frequency. It was present at 14.81% of the 2010 PI survey sample sites, with 4% overall relative frequency.

The good news is that Eurasian watermilfoil does not appear to have "taken over" the excellent and diverse aquatic plant community in Wolf Lake. Although it has remained well-established, it hasn't substantially increased its frequency –it has been under 5% relative frequency for over 5 years—nor in its growth density—it has been 4% or under relative density.

The bad news is that Eurasian watermilfoil appears to have hybridized with northern watermilfoil in Wolf Lake. Of Wisconsin's over 15,000 lakes, only about 40 have been verified as having a hybrid milfoil present by DNA testing. Research is still being done as to how a hybrid milfoil will respond to treatments historically used for Eurasian watermilfoil and how the hybrid may or may not spread differently than its parent species.

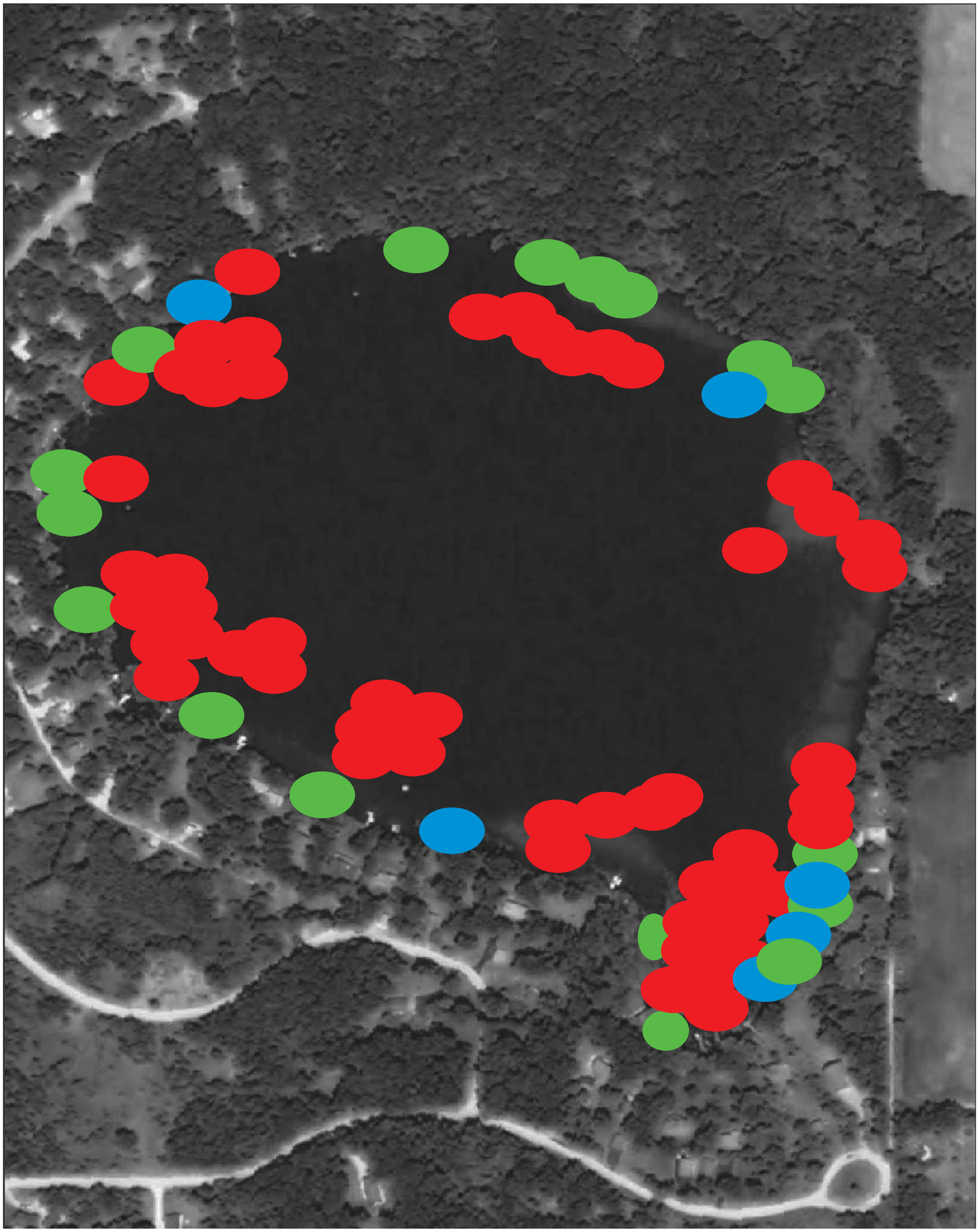


Figure 25: Distribution of Eurasian Watermilfoil and Reed Canarygrass in Wolf Lake 2010

Eurasian Watermilfoil Only Found	**Reed Canarygrass Only Found**	**Both Species Found**

THE COMMUNITY

The 2010 transect Simpson's Diversity Index (SI) score for Wolf Lake was .94, suggesting very good species diversity. This is up from the 2005 transect SI score of .91. A rating of 1.0 would mean that each plant in the lake was a different species (the most diversity achievable). The 2006 PI survey SI was .88; the 2010 PI survey SI was .93. The average SI range for all Wisconsin lakes is .8 to .9, so the SI for Wolf Lake is basically in the top quartile for all Wisconsin lakes when it comes to diversity. The North Central Hardwood Region, which includes Wolf Lake, has an average SI range is .82 to .9, so Wolf Lake is in the top quartile for diversity for its ecological region too (Nichols et al, 2000).

The Aquatic Macrophyte Community Index (AMCI) for the 2010 transect survey of Wolf Lake is 59, down 2 points from the 2005 figure of 61. Both these figures are above the average range for North Central Wisconsin Hardwood Lakes (average range 48 to 57) and all Wisconsin lakes (average range 45 to 57), placing Wolf Lake is the upper quartile of lakes in Wisconsin and in its region.

Figure 26: Aquatic Macrophyte Community Index 2005 v 2010 (T)

Parameter	2005 Value	2005 Score	2010 Value	2010 Score
max root depth	18	10	18	10
littoral veg%	100	10	100	10
% sub species	86	9	67	7
taxa number	32	10	50	10
exot %	6	5	7	5
SI diversity	0.91	9	0.94	10
sens %	15	8	12	6
total AMCI score		61		58

The AMCI for the 2010 PI aquatic plant survey was 59. This, too, is above the average range for North Central Hardwood Forests and for all Wisconsin lakes. The AMCI for the 2006 PI survey was 60.

Figure 27: AMCI 2006 v 2010 Wolf Lake (PI)

	2996	2006	2010	2010
Parameter	**Value**	**Score**	**Value**	**Score**
max root depth	22.5	10	20	10
% littoral	52.2	10	57.7	10
% sub	85	10	66	7
SI	0.88	8	6	5
# taxa	24	9	15	7
% sens	13	7	52	10
% exot	4	6	0.93	10
Total		60		59

For several years, Wolf Lake has gained permission from the WDNR to chemically spot-treat the Eurasian watermilfoil (EWM), which was 15% of the aquatic plant community in 2005. It appears from the 2010 surveys that the treatment regime has at least resulted in the EWM population remaining fairly stable, at about 4% to 5% of the aquatic plant population. However, that doesn't mean that the Wolf Lake Association should assume that Eurasian watermilfoil is "licked" at its lake. Careful watch will need to continue for both EWM and Curly-Leaf Pondweed.

A Coefficient of Conservatism and a Floristic Index calculation were performed on the field results. Technically, the average Coefficient of Conservatism measures the community's sensitivity to disturbance, while the Floristic Index measures the community's closeness to an undisturbed condition. Indirectly, they measure past and/or current disturbance to the particular community.

Previously, a value was assigned to all plants known in Wisconsin to categorize their probability of occurring in an undisturbed habitat. This value is called the plant's Coefficient of Conservatism. A score of 0 indicates a native or alien opportunistic invasive plant. Plants with a value of 1 to 3 are widespread native plants. Values of 4 to 6 describe native plants found most commonly in early successional ecosystem. Plants scoring 6 to 8 are native plants found in stable climax conditions. Finally, plants with a value of 9 or 10 are native plants found in areas of high quality and are often endangered or threatened. In other words, the lower the numerical value a plant has, the more likely it is to be found in disturbed areas.

The 2010 Average Coefficient of Conservatism from the transect method was 5.0, up slightly from the 2005 figure of 4.69. The 2010 figure for the PI survey was 4.94, about the same as the 2006 PI figure of 4.9. All these figures put Wolf Lake in the lowest quartile for Wisconsin Lakes (average 6.0) and for lakes in the North Central Hardwood Region (average 5.6). The aquatic plant community in Wolf Lake is in the category of those most tolerant of disturbance, probably due to selection by a series of past disturbances.

The Floristic Quality Index is also a tool that can be used to identify areas of high conservation value, monitor sites over time, assess the anthropogenic (human-caused) impacts affecting an area and measure the ecological condition of an area (M. Bourdaghs, 2006). The Floristic Quality Index for the 2010 transect survey was 34.64, up substantially from the 2005 transect figure of 26.52. The FQI for the 2010 PI survey was 34.29, up from the 2006 PI FQI of 22.1. The 2010 figures are above the average for all Wisconsin Lakes average (22.2) and the North Central Hardwood Region (average 20.9). This indicates that the plant community in Wolf Lake is farther from an undisturbed condition than the average lake in Wisconsin overall and in the North Central Hardwood Region.

At first glance, these numbers may seem contradictory. The Average Coefficient of Conservatism does not consider the frequency of occurrence of a particular species—it only measures what species were present at all and the number of species that were present. It doesn't measure what was dominant, abundant or common. Looking at just the number and identity of species present establishes that the aquatic plant community in Wolf Lake has been impacted by at least an average amount of any type of disturbance.

Disturbance" is a term that covers many disruptions to a natural community. It includes physical disturbances to plant beds such as boat traffic, plant harvesting, chemical treatments, dock and other structure placements, shoreline development and fluctuating water levels. Indirect disturbances like sedimentation, erosion, increased algal growth, and other water quality impacts will also negatively affect an aquatic plant community. Biological disturbances such as the introduction of non-native and/or invasive species (such as the Eurasian Watermilfoil, Curly-Leaf Pondweed and Reed Canarygrass found here), destruction of plant beds, or changes in aquatic wildlife can also negatively impact an aquatic plant community.

However, the Floristic Quality Index can be adjusted for frequency of occurrence. Looking at those numbers, the 2010 transect survey had a FQI of 34.9 and the 2010 PI survey had a FQI of 34.3. The FQI is a useful tool for evaluating human-caused disturbance, rather than overall disturbance. Using that tool, the 2010 FQI scores suggest that human-caused disturbances have so far not had a significant impact on the aquatic plant community in Wolf Lake.

Figure 28: Floristic Quality and Coefficient of Conservatism of Wolf Lake, Compared to Wisconsin Lakes and Northern Wisconsin Lakes.

	Average Coefficient of Conservatism †	Floristic Quality ‡
Wisconsin Lakes	5.5, 6.0, 6.9 *	16.9, 22.2, 27.5
NCHR	5.2, 5.6, 5.8 *	17.0, 20.9, 24.4
Wolf Lake 2010	4.9, 5.0	34.29, 34.64

* - Values indicate the highest value of the lowest quartile, the mean and the lowest value of the upper quartile.
† - Average Coefficient of Conservatism for all Wisconsin lakes ranged from a low of 2.0 (the most disturbance tolerant) to a high of 9.5 (least disturbance tolerant).
‡ - lowest Floristic Quality was 3.0 (farthest from an undisturbed condition) and the high was 44.6 (closest to an undisturbed condition).

Since many of the Wolf Lake shores had a substantial amount of native vegetation, native shore, calculating Average Coefficient of Conservationism, Floristic Quality Index, Simpson's Index of Diversity and Aquatic Macrophyte Community Index to compare disturbed to undisturbed shorelines doesn't seem appropriate in the case of Wolf Lake.

V. COMPARISON TO PRIOR YEARS

Results of the 2005 and 2010 transect surveys were compared using a number of parameters. The number of sites with emergent aquatic plants went up substantially, as did the number of sites with submergent plants. Free-floating plants were found in 2010, but not found in 2005. Rooted floating-leaf plants stayed at about the same frequency of occurrence While the AMCI went down slightly, the Simpson's Index of Diversity, the Average Coefficient of Conservatism, the Floristic Quality Index and species richness all went up, as did the number of species.

Figure 29: Comparison of Plant Communities 2005 v 2010 (T)

CHANGE IN COMMUNITY	2005	2010	Change	% Change
Number of Species	32	50	18.00	56.25%
Maximum Rooting Depth	18	18	0.00	0.00%
% of Littoral Zone Unvegetated	0.0	0.0	0.00	0.00%
%Sites/Emergents	23.1	28.3	5.20	22.51%
%Sites/Free-floating	none	5.0	5.00	100.00%
%Sites/Submergents	92.2	100.0	7.80	8.46%
%Sites/Floating-leaf	25.0	30.0	5.00	20.00%
Simpson's Diversity Index	0.91	0.94	0.03	3.30%
Species Richness	5.4	6.2	0.80	14.81%
Floristic Quality	26.52	34.64	8.12	30.62%
Average Coefficient of Conservatism	4.7	5.0	0.30	6.38%
AMCI Index	61	58	-3.00	-4.92%

Results of the 2006 and 2010 PI surveys were also compared. The frequency of emergent plants went up, as did the frequency of floating-leaf rooted plants. While the AMCI went down slightly, the Simpson's Index of Diversity, the Average Coefficient of Conservatism, the Floristic Quality Index and species richness all went up, as did the number of species.

A number of species, especially emergent species, have appeared since 2005 and 2006. Submergent species have also increased slightly. Much of this increase can likely be attributed to the fact that in 2005 and 2006, Adams County was the in the middle of a drought, causing lower lake levels than those in 2010. In 2010, all sites could be reached, while in 2006, some sites could not, and in 2005, the water depth zones started out further out, due to lack of water in the usual near shore area.

Figure 30: Comparison of Plant Communities 2006 vs 2010 (PI)

WOLF (PI)	2006	2010	Change	% Change
Number of Species	24	51	27	112.50%
Maximum Rooting Depth	22.5	18	-5	-20.00%
% of Littoral Zone Unvegetated	24.4	22.2	-2	-9.02%
%Sites/Emergents	3.0	11.1	8	270.00%
%Sites/Free-floating	0.7	4.4	4	528.57%
%Sites/Submergents	71.9	75.6	4	5.15%
%Sites/Floating-leaf	5.2	12.6	7	142.31%
Simpson's Diversity Index	0.88	0.93	0	5.68%
Species Richness	1.4	2.5	1	78.57%
Floristic Quality	22.26	34.29	12	54.04%
Average Coefficient of Conservatism	4.9	4.9	0	0.00%
AMCI Index	60	59	-1	-1.67%

The results of the 2005 and 2010 transect surveys were also compared using Jaccard's coefficient of similarity. This procedure allows two communities to be compared for similarity and dissimilarity. A coefficient of .75 or more suggests that the communities are statistically similar. When these calculations were performed using actual frequency of occurrence and relative frequency of occurrence, the 2005 and 2010 transect aquatic plant communities scored as 66.61% similar on the basis of actual frequency of occurrence and 83.6% on the basis of relative frequency.

Similar calculations were done on the 2006 and 2010 PI survey results. These results suggested that the 2006 PI aquatic plant community and that of the 2010 PI survey were <u>not</u> substantially similar, since there coefficient of similarity was only 50.4% based on actual frequency of occurrence and 60.5% based on relative frequency. Sometimes these figures have to be evaluated carefully; for example, free-floating plants only occurred at less than 1% of the PI sites in 2006, but at 4.4% of the PI sites in 2010. Although the increase was over 528%, the amount of change in that part of the community was not particularly significant overall.

The change in water level between 2005-2006 and 2010 may account for at least part of this difference. Areas exposed in 2005 and 2006 to the sun were covered by water in 2010, allowing activation of aquatic plant seedbeds by 2010. This addition of species accounts for much of the calculation results. In fact, this process suggests why it is important to have on-going evaluations of a lake's aquatic plant community, rather than just a one-time survey. Unlike man-made lakes, where water level can be manipulated by humans, natural lakes all have a cycle controlled by nature in various aspects (heat, sun, groundwater, rain & snowfall, drainage patterns, etc.). Many of these cycles are beyond human lifespans. Thus, having a pattern of aquatic plant community evaluations over several years provides some "snapshot" of what is going on in the lake cycle. The differences between 2005/2006 and 2010 alone are not enough to draw a long-term conclusion about Wolf Lake's aquatic community health. Surveys will need to be continue to be done before one could conclude that the aquatic plant community had actually changed for the long-term.

VI. CONCLUSION

Based on water clarity, chlorophyll and phosphorus data, Wolf Lake is an oligotrophic/mesotrophic seepage lake with good to very good water clarity and good to very good water quality. This trophic state should support moderate plant growth and only occasional, localized algal blooms.

Sufficient nutrients (trophic state) and high water at Wolf Lake favor plant growth. Although sometimes sand sediment may limit aquatic plant growth, this does not seem to be the case in Wolf Lake. Over 2/3 of the littoral zone of the lake is vegetated (in water less than 25 feet deep), suggesting that all the sediments in Wolf Lake hold sufficient nutrients to maintain aquatic plant growth.

Aquatic vegetation occurred at 100% of the transect sample sites, with 94% of the sites having rooted aquatic plants. The maximum rooting depth, based on water clarity figures, is the less than the found rooted aquatic plant growth. The 0 to 1.5 foot depth zone had the highest frequency of occurrence and growth density in the 2010 transect survey. Nearly 80% of the PI points in 2010 were also vegetated.

The lake does have a good mixture of emergent, rooted floating-leaf and rooted plants. From the transect survey, based on relative frequency, 27% of the species are emergent, 2% are free-floating plants, 6% are rooted floating-leaf plants and 67% are submergent species. From the PI survey, 17% of the species were emergent, 1% were free-floating plants, 4% were rooted floating-leaf plants, and 78% were submergent species.

Emergents provide important fish habitat and spawning areas, as well as food and cover for wildlife. Floating-leaf plants provide cover for fish and invertebrates, as well as help dampen waves to protect the shore. Filamentous algae were present. A diverse submergent community provides many benefits. Because this lake provides all structural types of vegetation, the aquatic plant community has a diversity of structure and species that supports even more diversity of fish and wildlife.

In the 2010 transect survey, 50 aquatic species were found. Of these, 50 were native species: 22 emergents; 2 floating-leaf rooted plants; 2 free-floating species; 20 were submergents; and 2 were plant-like algae (*Chara* and *Nitella)*. The 2010 PI survey found 52 aquatic species. Of these, 50 were native: 24 emergent species; 2 free-floating species; 2 floating-leaf rooted plants; 20 submergent species; and 2 macrophytic algae. The two invasives found were Eurasian watermilfoil and Reed canarygrass, both of which had been found previously at Wolf Lake.

While the level of *Myriophyllum spicatum* (Eurasian Watermilfoil) appears to be remaining fairly stable, this has required ongoing chemical treatment of this invasive. At this point, the population of the other submergent invasive that has been found in Wolf Lake, Curly-Leaf Pondweed, appears to be remaining small. Reed Canarygrass, the invasive emergent present at Wolf Lake, is also only a limited part of the aquatic plant community so far. There are local citizens on Wolf Lake trained in aquatic invasive species monitoring. That monitoring should continue to make sure any expansion of these invasives is caught early.

Many of the species found in Wolf Lake have multiple uses for wildlife.

FIGURE 31: BENEFITS OF SOME AQUATIC PLANTS

	Fish	Water Fowl	Shore Birds	Upland Birds	Muskrat	Beaver	Deer
Ceratophyllum demersum	F,I,C,S	F,I,C			F		
Chara spp	F,S	F,I,C					
Eleocharis palustris	F,I,C,S	F,I,C	F,C		F	F	
Elodea canadensis	F,I,C	F,I,C			F		
Iris versicolor	F,C,I	F,C	F,C		F	F	
Lemna minor	F,I,C,S	F	F		F	F	
Myriophyllum heterophyllum	F,I,C,S	F,I	F		F		
Myriophyllum sibiricum	F,I,C,S	F,I	F		F		
Najas flexilis	F.C	F	F				
Phalaris arundinacea	C	C					
Potamogeton amplifolius	F,I,C,S	F,I	F		F	F	F
Potamogeton foliosus	F,I,C,S	F,I	F		F	F	F
Potamogeton praelongus	F,I,C,S	F,I	F		F	F	F
Potamogeton pusillus	F,I,C,S	F,I			F		
Potamogeton richardsonii	F,I,C,S	F,I	F		F	F	F

Potamogeton zosteriformis	F,I,C,S	F,I	F		F	F	F
Sagittaria spp	I,C	F	F		F	F	F
Schoenoplectus tabernaemontani	F,C,I	F,C	F,C,N	F	F	F	F
Stuckenia pectinata	F,I,C,S	F,I	F		F	F	F
Typha latifolia	I,C,S	F	F,C,N		F,C,N	F	

F = Food; I = Shelters Invertebrates; C = Cover; S = Spawning; N = Nesting

The Wolf's Diversity Index for Wolf Lake was .94 for the 2010 transect survey, suggesting good species diversity, and .93 for the 2010 PI survey, excellent species diversity. The Aquatic Macrophyte Community Index (AMCI) for Wolf Lake is 58 for the transect survey in 2010 and 59 for the PI survey. These figures are both above the averages for all Wisconsin lakes and the North Central Hardwood region. However, the Average Coefficients of Conservatism in 2010 put Wolf Lake in the group of lakes most tolerant of disturbance in Wisconsin lakes and lakes in the North Central Hardwood Region. But the Floristic Quality Indices of the aquatic plant community in Wolf Lake for the 2010 transect and PI surveys were above average for all Wisconsin Lakes and lakes in the North Central Hardwood Region. This suggests that the aquatic plant community in Wolf Lake has been impacted by some disturbances, although the amount of that disturbance may depend on the area of the lake being examined.

Native herbaceous and wooded shore cover were the most frequently-occurring shoreline cover in 2010 in Wolf Lake, since they were found at 100% of the sample sites. Along with native shrub cover, they comprised about 87% of the shore cover. Of the disturbed areas of the shore, hard structure (which includes piers, walkways, patios, etc.) was the most frequently-occurring shore cover. Cultivated lawn continued to be encountered at 25% of the sites, covering about 7% of the shore.

Most of Wolf Lake's shoreline offers relatively good protection for water quality. Some of buffers present were only a few feet wide landward and could add greater protection to the water quality if they were expended. the and have significant potential to negatively impact Wolf Lake's water by increased runoff (including lawn fertilizers, pet waste, pesticides) and shore erosion.

The boat ramp at Wolf Lake presents a problem that needs to be addressed soon. It is paved and located at the bottom of a steep paved drive. Runoff from the road (Fern Lane) goes down the steep paved hill directly into the lake. Because of some relatively large rainstorms in the past few years, this has also resulted in part of the boat ramp area being washed out, so that currently there are big pits in the pavement (one about 2 feet deep).

Wolf Lake is a oligotrophic to mesotrophic lake with good to very good water quality and high water clarity. The quality of the aquatic plant community in Wolf Lake is above average for Wisconsin lakes and for lakes in the North Central Hardwood region. Structurally, it contains emergent plants, rooted plants with floating leaves, free-floating plants, and submergents.

The most frequent and dominant plant in the lake was actually a macrophytic algae, *Chara* spp. 100% of the transect sites (all in the littoral zone) and nearly 78% of the PI littoral zone sites had rooted aquatic plants. *Chara* spp was the only species to occur at a frequency of more than 50% in the PI survey; in the 2010 transect survey, both *Chara* spp and *Myriophyllum sibiricum* had a more than 50% frequency occurrence.

A healthy and diverse aquatic plant community plays a vital role within the lake ecosystem. Plants help improve water quality by trapping nutrients, debris and pollutants in the water body; by absorbing and/or breaking down some pollutants; by reducing shore erosion by decreasing wave action and stabilizing shorelines and lake bottoms; and by tying-up nutrients that would otherwise be available for algae blooms. Aquatic plants provide valuable habitat resources for fish and wildlife, often being the base level for the multi-level food chain in the lake ecosystem, and also produce oxygen needed by animals.

Further, a healthy and diverse aquatic plant community can better resist the invasion of species (native and non-native) that might otherwise “take over” and create a lower quality aquatic plant community. A well-established and diverse plant community of natives can help check the growth of more tolerant (and less desirable) plants that would otherwise crowd out some of the more sensitive species, thus reducing diversity.

Vegetated lake bottoms support larger and more diverse invertebrate populations that in turn support larger and more diverse fish and wildlife populations (Engel, 1985). Also, a mixed stand of aquatic macrophytes (plants) supports 3 to 8 times more invertebrates and fish than do monocultural stands (Engel, 1990). A diverse plant community creates more microhabitats for the preferences of more species.

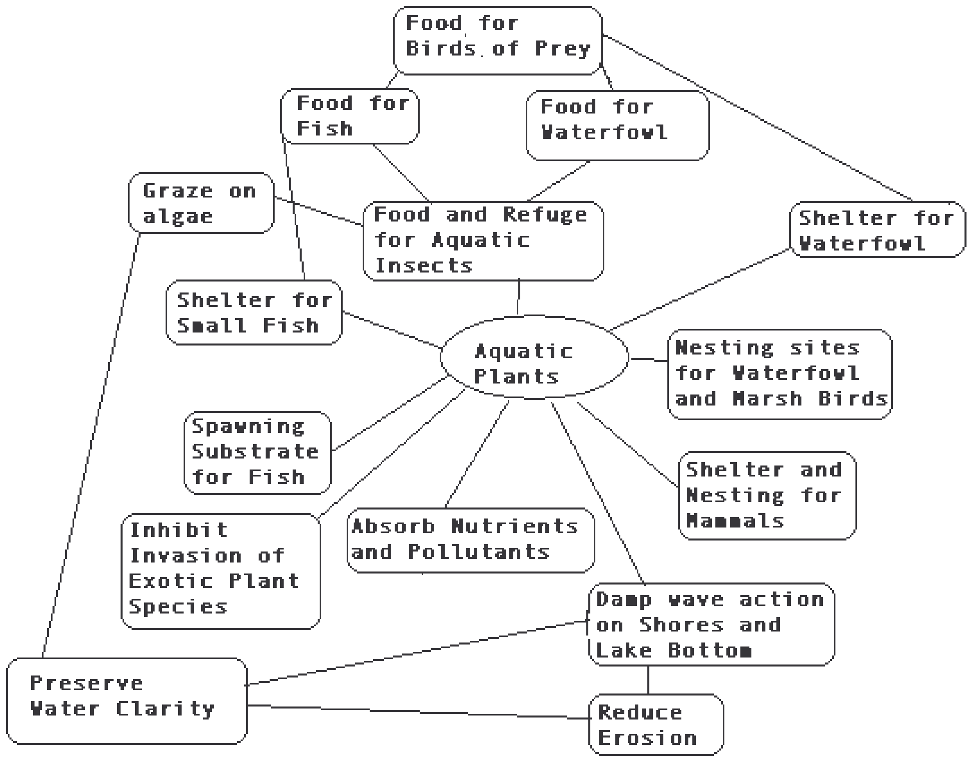


Figure 32: Aquatic Ecosystem Web

MANAGEMENT RECOMMENDATIONS

1) Wolf Lake does have a lot of native vegetated shoreline, but some of the buffers need to be wider landward to get maximum benefit to the water quality, especially with the steep slopes around Wolf Lake.

2) The Wolf Lake Association needs to update its aquatic plant management plan. This plan should be incorporated into the overall lake management plan.

3) Wolf Lake current has an old aquatic plant management plan, but does not have a lake management plan. The Wolf Lake Association has been considering drafting a lake management plan. It is recommended that the Lake Association follow through with writing a lake management plan, so that the lake can be managed as a cohesive whole. The plan, once written, needs to be regularly reviewed and updated.

4) No lawn chemicals should be used on properties around the lake. If they must be used, they should be used no closer than 50 feet to the shore.

5) Since the native weevils that attack Eurasian watermilfoil were found previously in Wolf Lake, consideration should be given to taking steps to increase the population, if possible. This would reduce the amount of chemicals that need to be used to control the current population of EWM.

6) No broad-scale chemical treatments of native aquatic plant growth are recommended due to the undesirable side-effects of such treatments, including increased nutrients from decaying plant material, destruction of fish and wildlife habitat, and decreased dissolved oxygen and opening up more areas to the invasion of EWM.

7) Fallen trees should be left at the shoreline. They should not be removed unless they block access to the lake. Recently, a large weeping willow tree fell, which would have provided a great deal of habitat, but it was removed. The lake association could pursue the addition of fallen trees as habitat.

8) Wolf Lake residents should continue to be involved in the Wisconsin Self-Help Monitoring Program to permit on-going monitoring of the lake trends for basically no cost. This should include monitoring for known invasives and a possible hybrid milfoil.

9) Wolf Lake residents should identify, cooperate with and participate in watershed programs that will reduce nutrient and sediment inputs.

10) Emergent vegetation and lily pad beds should be protected where it is currently present and re-established where it is not. These not only provide habitat, but also help stabilize the sandy shores.

11) Shore areas where there is undisturbed wooded shore should be maintained & left undisturbed.

12) Since critical habitat areas have been determined on Wolf Lake, care should be taken to reduce any disturbance in those areas. Posting a map of these areas by the boat ramp might help lake users to avoid disturbing these areas.

13) The Wolf Lake Association, with the assistance of the Adams County Land & Water Conservation Department, the Adams County Highway Department, the Wisconsin Department of Transportation and the Town of Jackson should develop and implement protective measures to reduce runoff from Fern Lane into Wolf Lake.

14) The boat ramp should be repaired. As it is, it presents a physical hazard and potential liability.

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